

[Fig. 2]

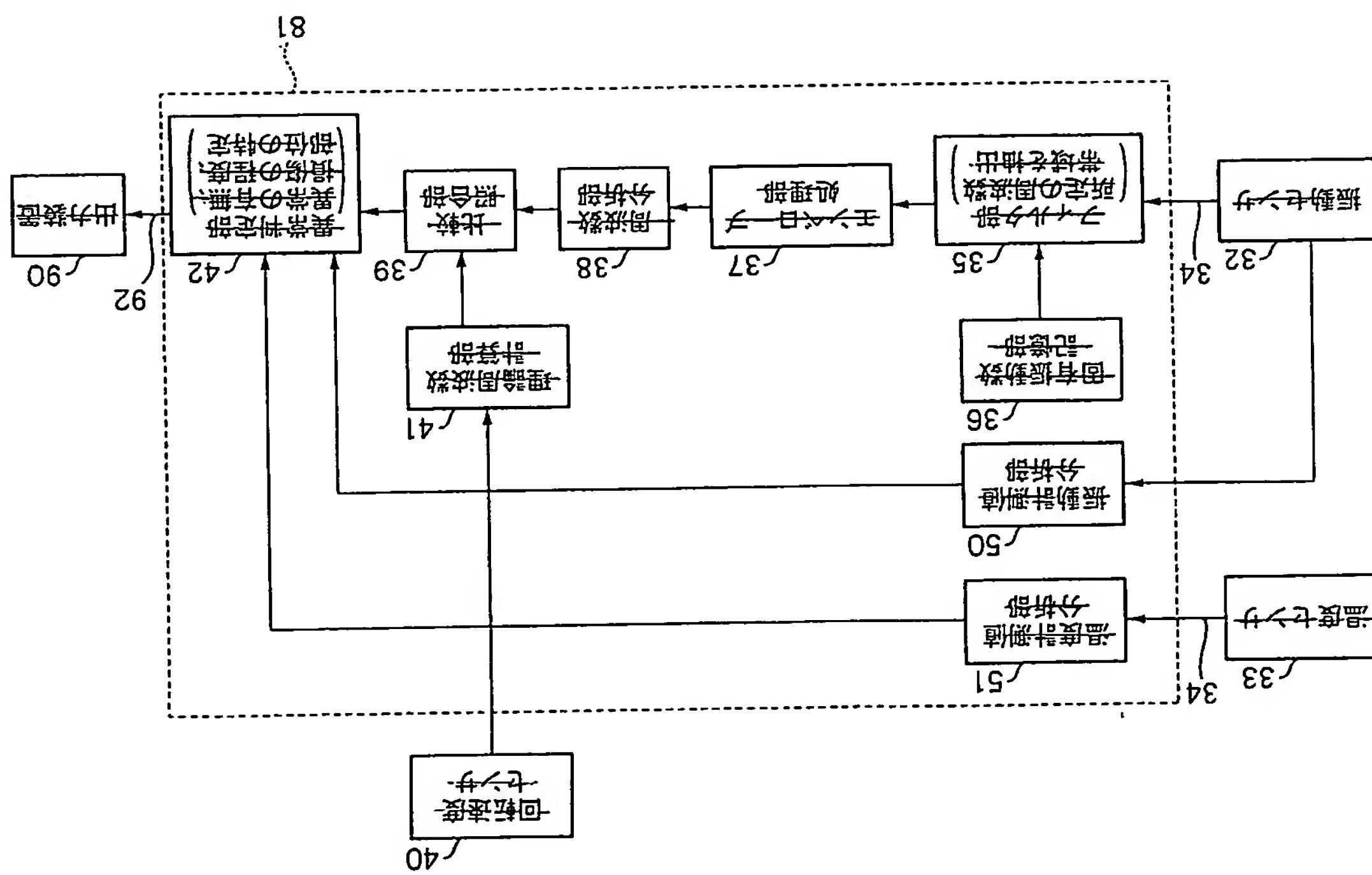
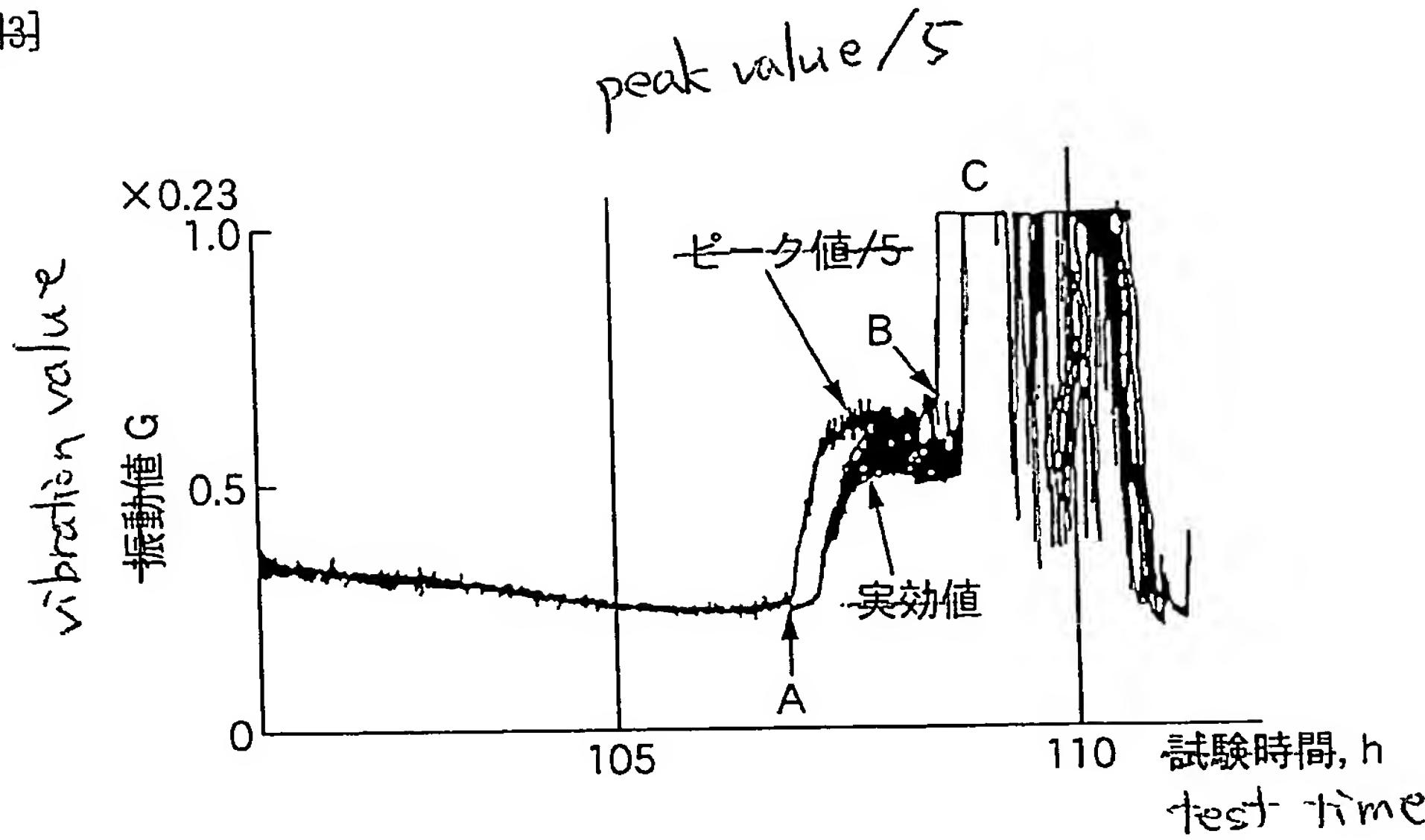


Fig. 3

[図3]



[図4]

Fig. 4

Temperature at outer diameter  
 surface of outer ring

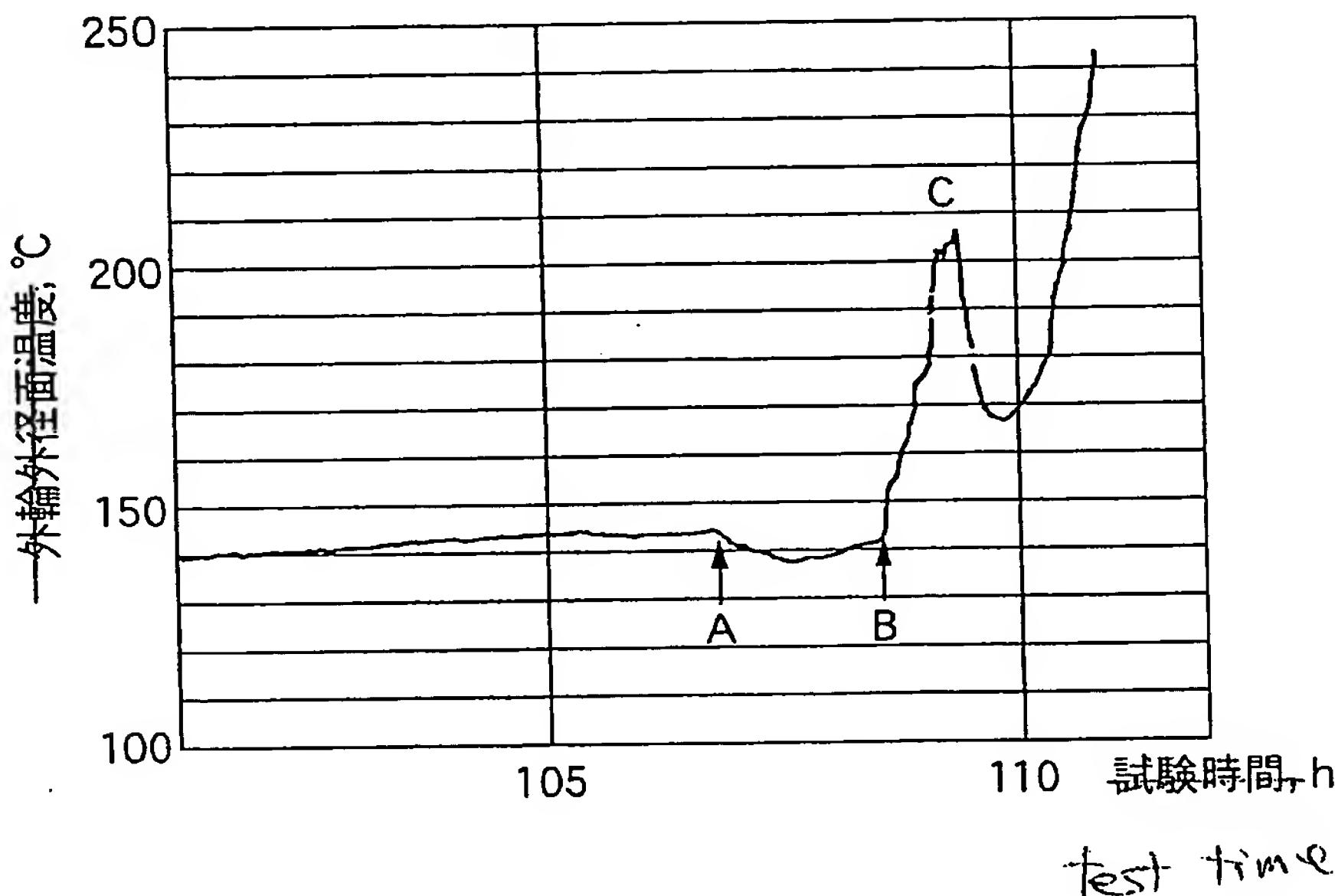


Fig. 5

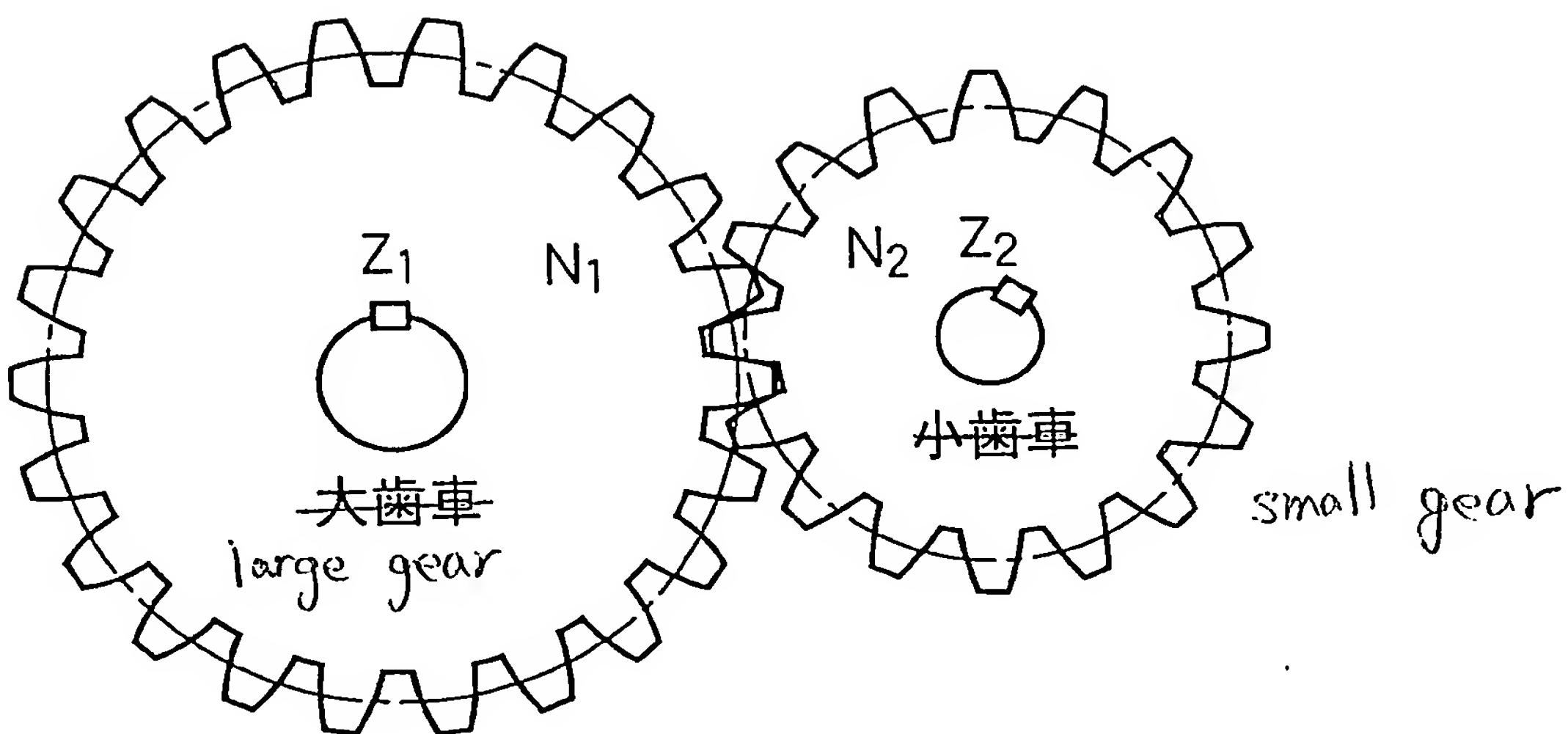
[図5]

軸受の部位 (Sx) portion of bearing	部位に対応する周波数 frequency corresponding to the portion
内輪 (Si) inner ring	$Z_{fi} = \frac{fr}{2} \left( 1 + \frac{Da}{dm} \cdot \cos \alpha \right) Z$
外輪 (So) outer ring	$Z_{fc} = \frac{fr}{2} \left( 1 - \frac{Da}{dm} \cdot \cos \alpha \right) Z$
転動体 (Sb) rolling element	$2fb = fr \left( 1 - \frac{Da^2}{dm^2} \cdot \cos^2 \alpha \right) \frac{dm}{Da}$
保持器 (Sc) retainer	$fc = \frac{fr}{2} \left( 1 - \frac{Da \cdot \cos \alpha}{dm} \right)$

$fr$ : 内輪(外輪)回転速度 [Hz]  $Z$ : 転動体の数  
 $fc$ : 保持器回転速度 [Hz]  $fi$ :  $fr - fc$   
 $fb$ : 転動体自転速度 [Hz]  $Da$ : 転動体直徑 [mm]  
 $dm$ : 転動体ピッチ円徑 [mm]  $\alpha$ : 接触角 [rad]

$fr$ : inner (outer) ring rotational speed [Hz]  
 $fc$ : retainer rotational speed [Hz]  
 $fb$ : rolling member rotating speed [Hz]  
 $dm$ : rolling element · pitch circle diameter [mm]  
 $Z$ : number of rolling element  
 $Da$ : rolling member diameter [mm]  
 $\alpha$ : contact angle [rad]

—[図6]— Fig. 6



かみ合い周波数成分:  $Sg = Z_1 \times \frac{N_1}{60}$  or  $Sg = Z_2 \times \frac{N_2}{60}$   
 mesh frequency component

$N_1$ : 大歯車の回転数( $\text{min}^{-1}$ )

$N_2$ : 小歯車の回転数( $\text{min}^{-1}$ )

$Z_1$ : 大歯車の歯数

$Z_2$ : 小歯車の歯数

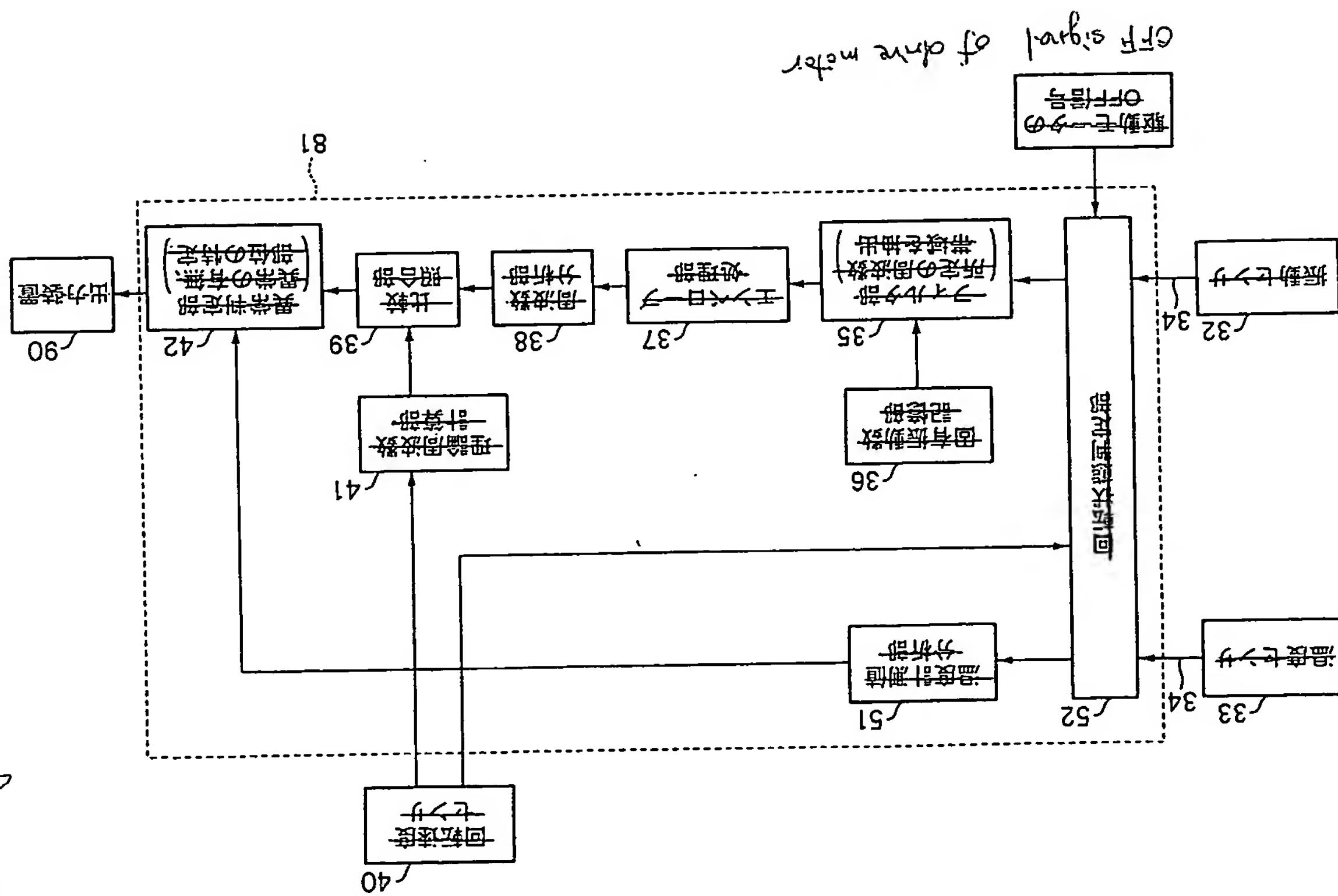
$N_1$ : rotational speed of large gear ( $\text{min}^{-1}$ )

$N_2$ : rotational speed of small gear ( $\text{min}^{-1}$ )

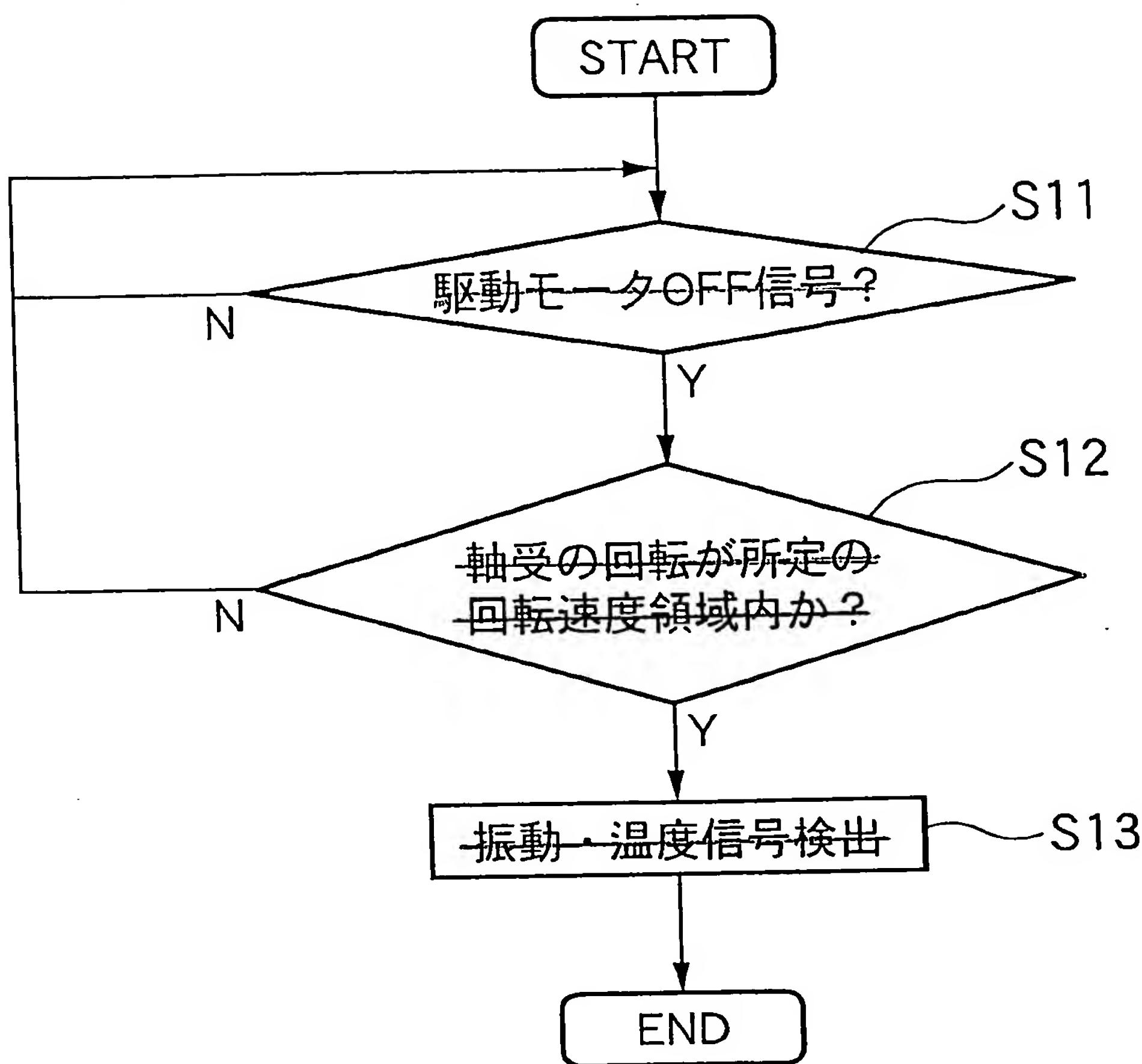
$Z_1$ : teeth number of large gear

$Z_2$ : teeth number of small gear

[Fig. 7]



[図8] Fig. 8



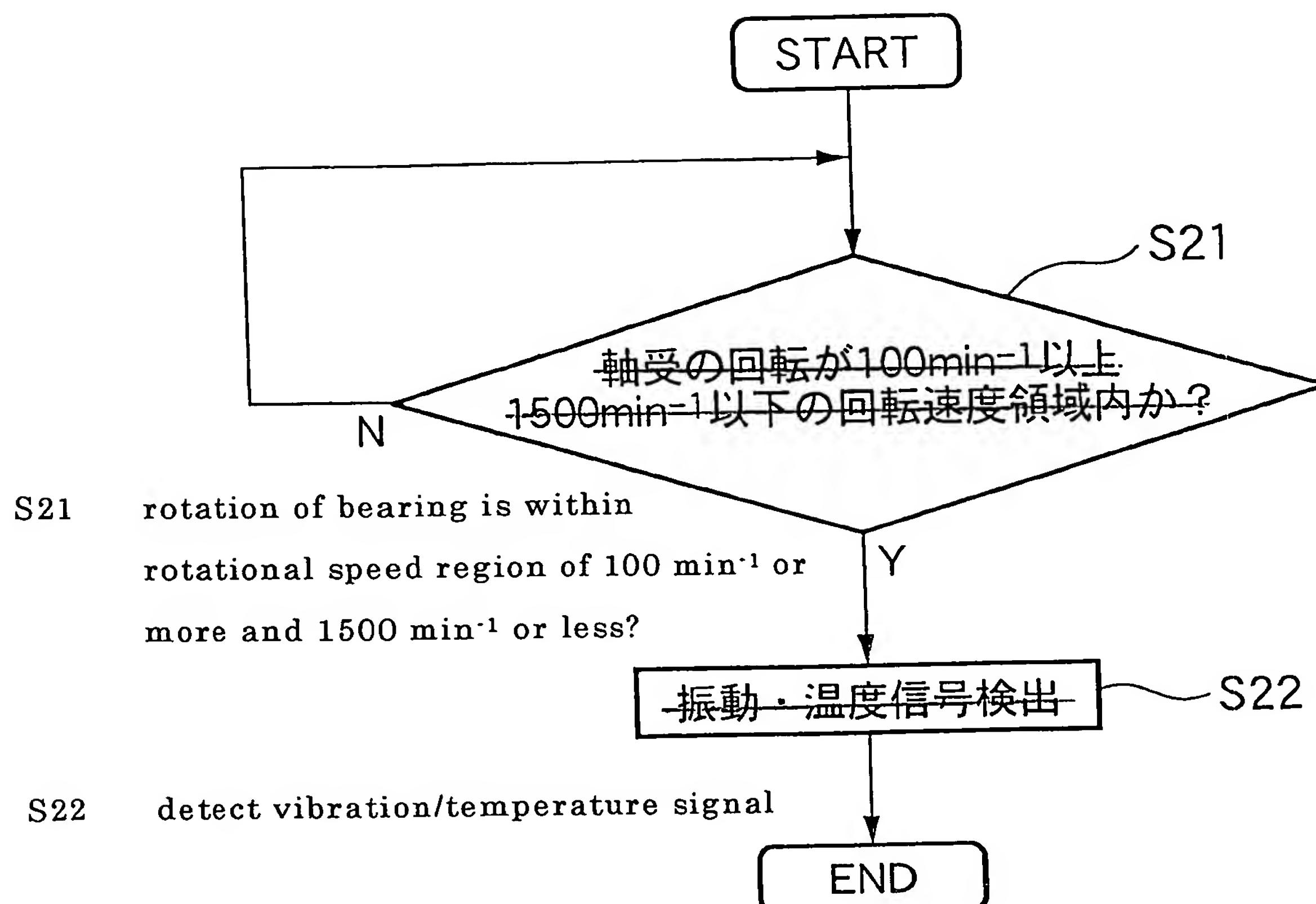
S11 drive motor OFF signal?

S12 rotation bearing is within predetermined rotational speed  
region?

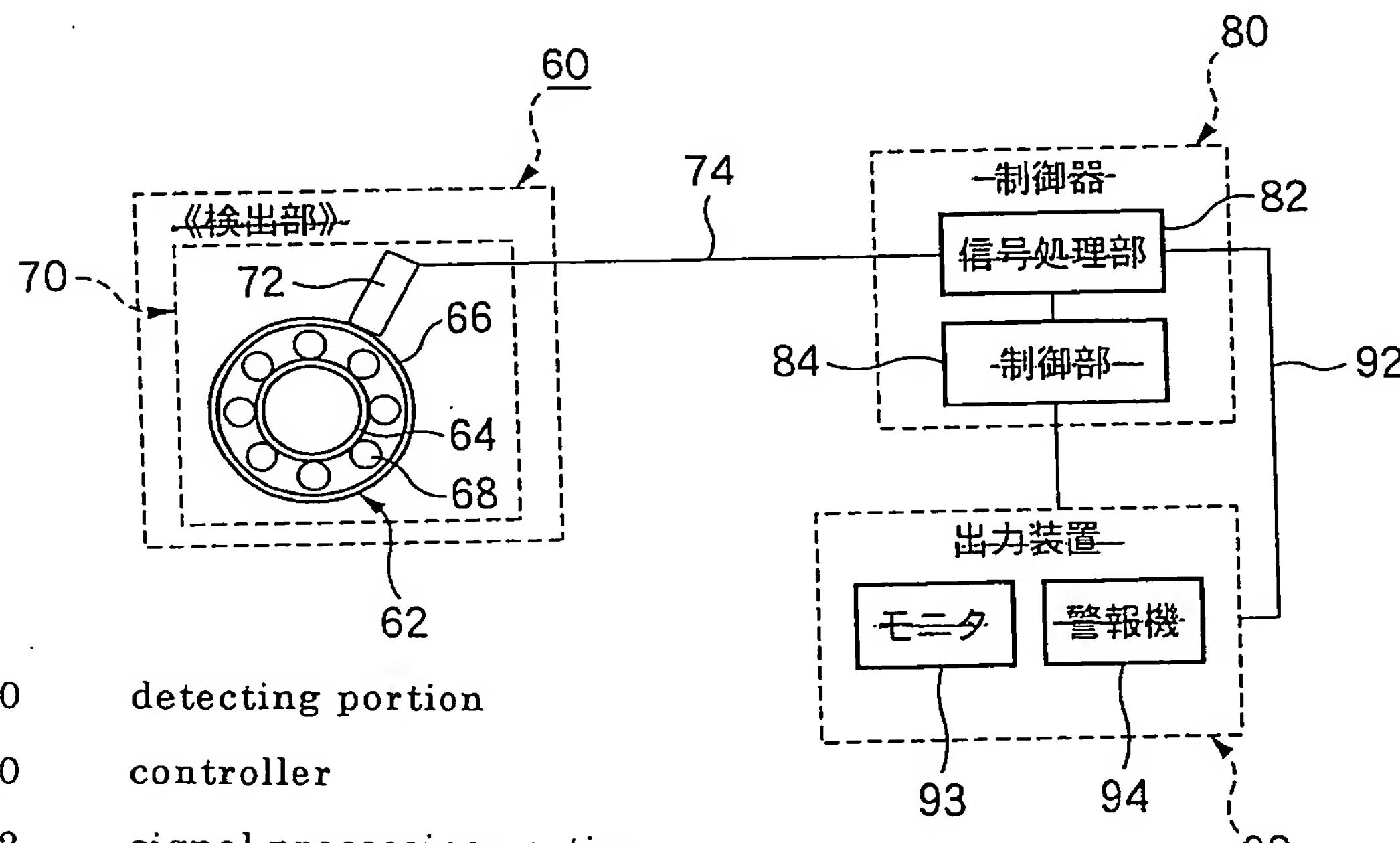
S13 detect vibration/temperature signal

202-293-7060

[図9] Fig. 9

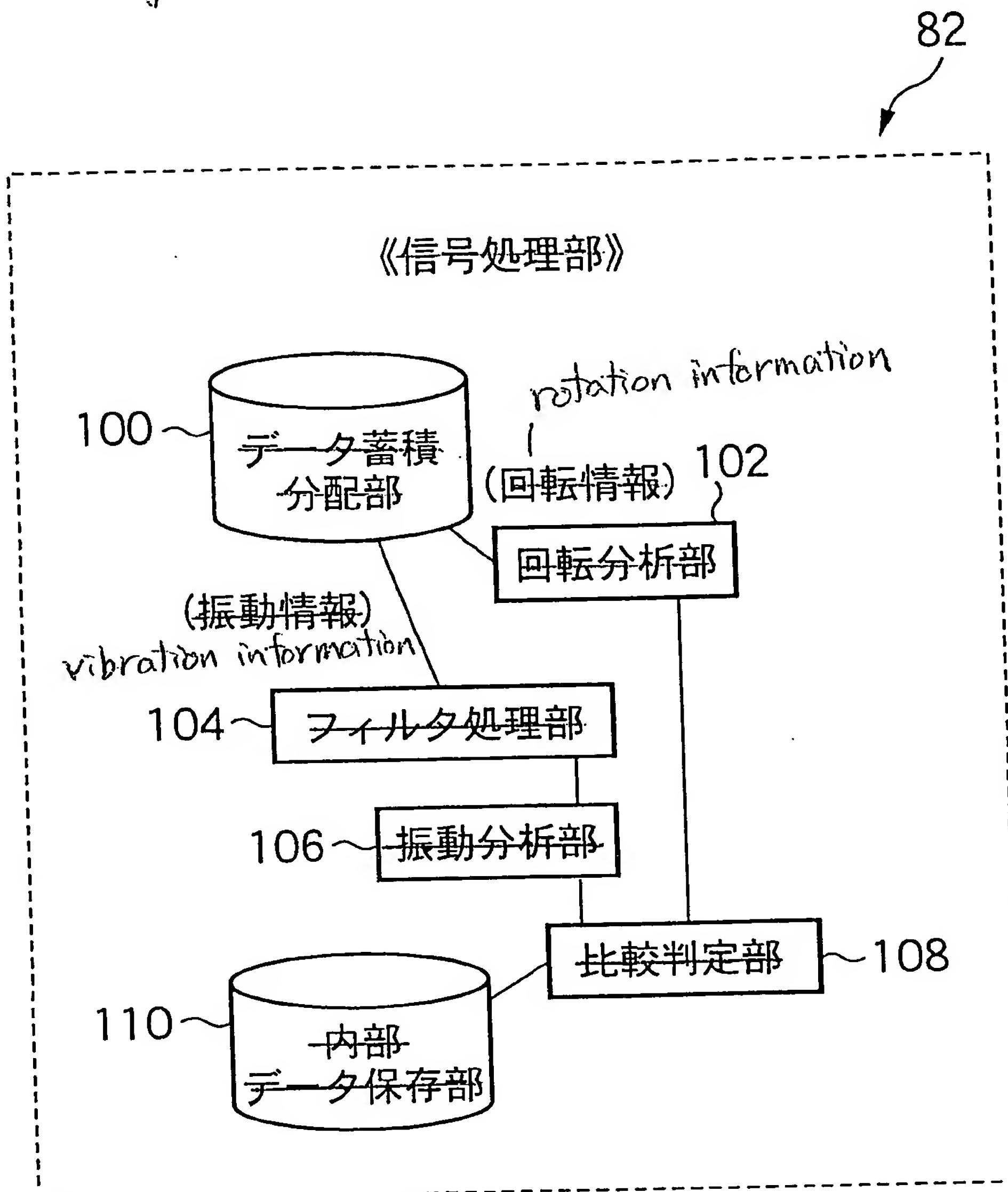


[図10] Fig. 10



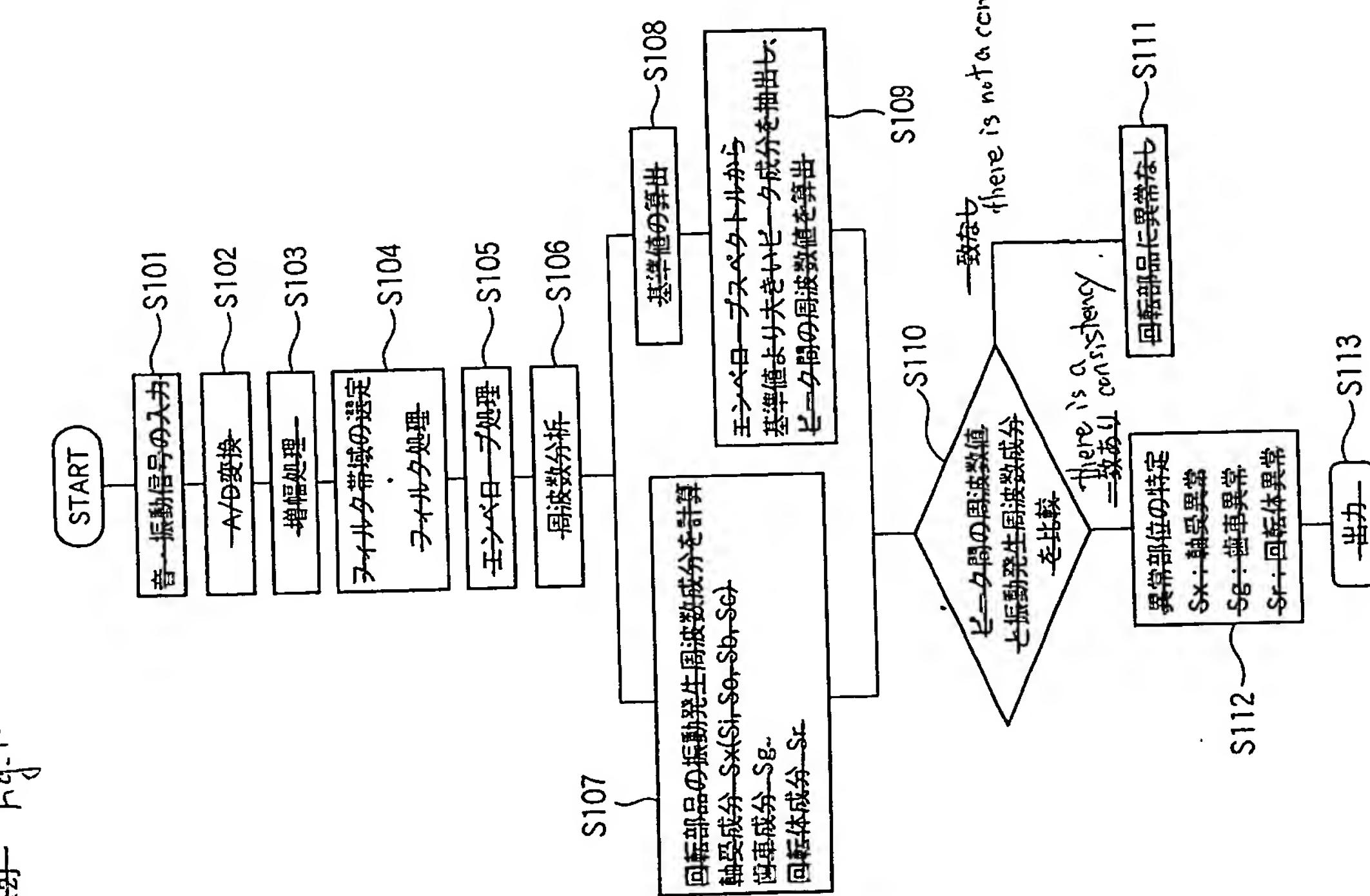
- 60 detecting portion
- 80 controller
- 82 signal processing portion
- 84 controlling portion
- 90 outputting unit
- 93 monitor
- 94 alarm

[図11] Fig. 11



- 82 signal processing portion
- 100 data accumulating and distributing portion
- 102 rotation analyzing portion
- 104 filter processing portion
- 106 vibration analyzing portion
- 108 comparing and determining portion
- 110 internal data holding portion

Fig. 12  
[Fig. 12]



[Fig. 12]

S101 input sound/vibration signal

S102 A/D conversion

S103 amplifying processing

S104 select filter band and filter processing

S105 envelope processing

S106 frequency analysis

S107 calculate vibration generating frequency component of rotating part

S108 calculate reference value

S109 sample, peak component larger than reference value from envelope spectrum and calculate frequency value between peaks

S110 compare frequency value between peaks and vibration generating frequency component

S111 rotating member is not abnormal

S112 specify abnormal portion

Sx: bearing abnormal

Sg: gear abnormal

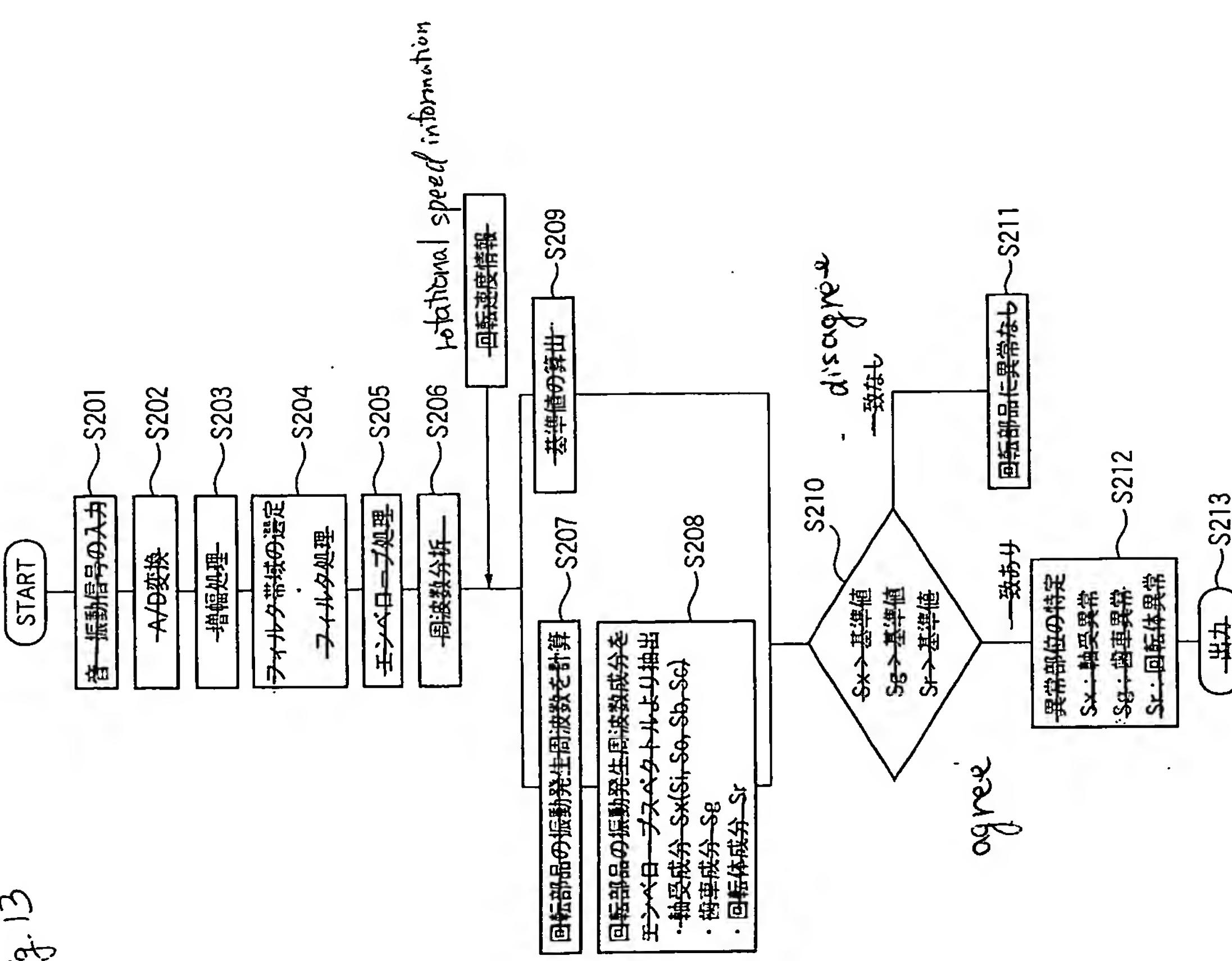
Sr: rotating member abnormal

S113 output

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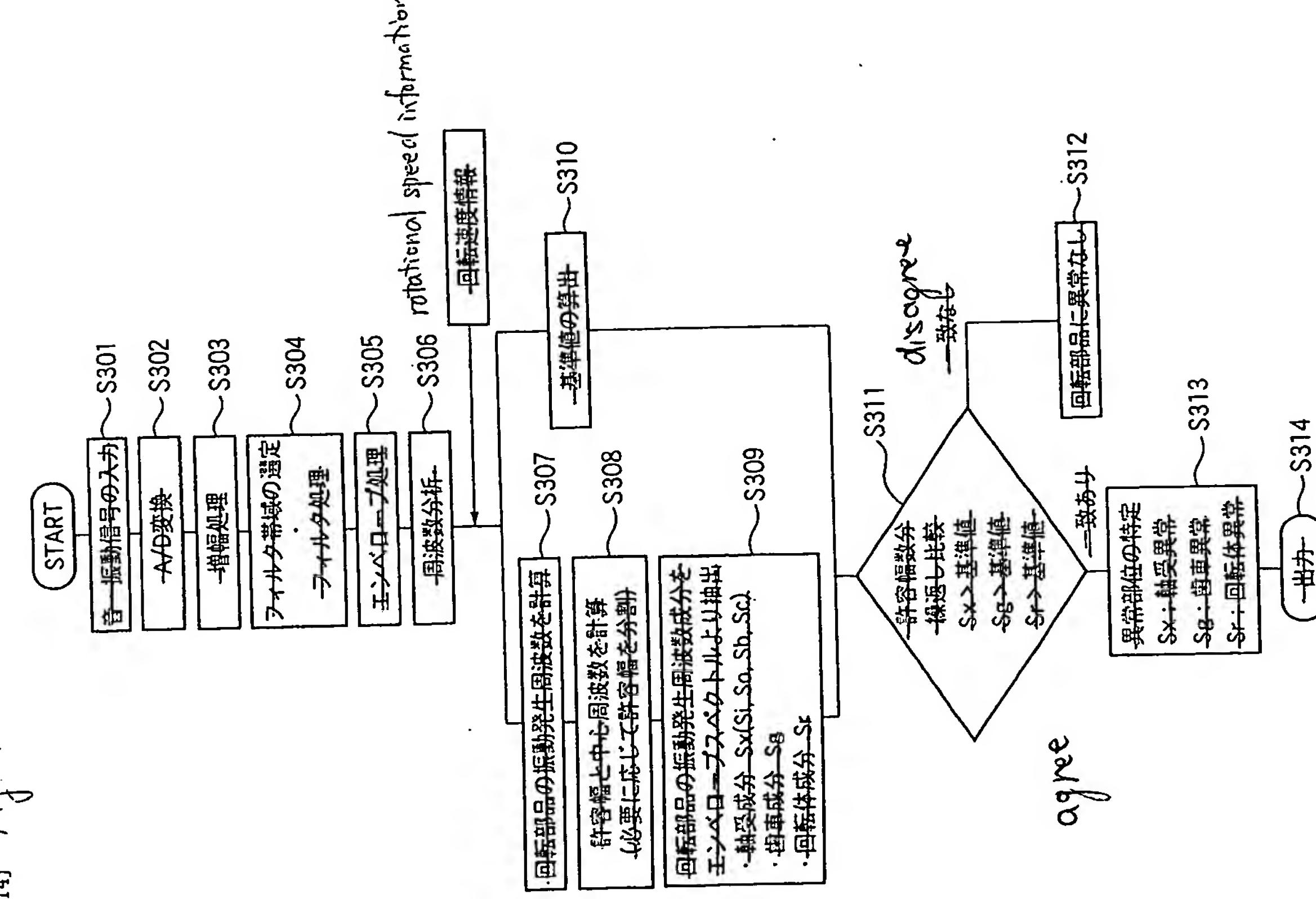
Fig. 13

Fig. 13



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Fig. 14



[Fig. 14]

S301 input sound/vibration signal

S302 A/D conversion

S303 amplifying processing

S304 select filter band and filter processing

S305 envelope processing

S306 frequency analysis

S307 calculate vibration generating frequency of rotating part

S308 calculate allowable width and central frequency (divide  
table width as necessary)

S309 sample vibration generating frequency component of  
ng part from envelope spectrum

S310 bearing component  $S_x$  ( $S_i$ ,  $S_o$ ,  $S_b$ ,  $S_c$ )

S311 gear component  $S_g$

S312 rotating member component  $S_r$

S313 calculate reference value

S314 repeatedly compare amount of allowable width number

S315  $S_x >$  reference value

S316  $S_g >$  reference value

S317  $S_r >$  reference value

S318 rotating member is not abnormal

S319 specify abnormal portion

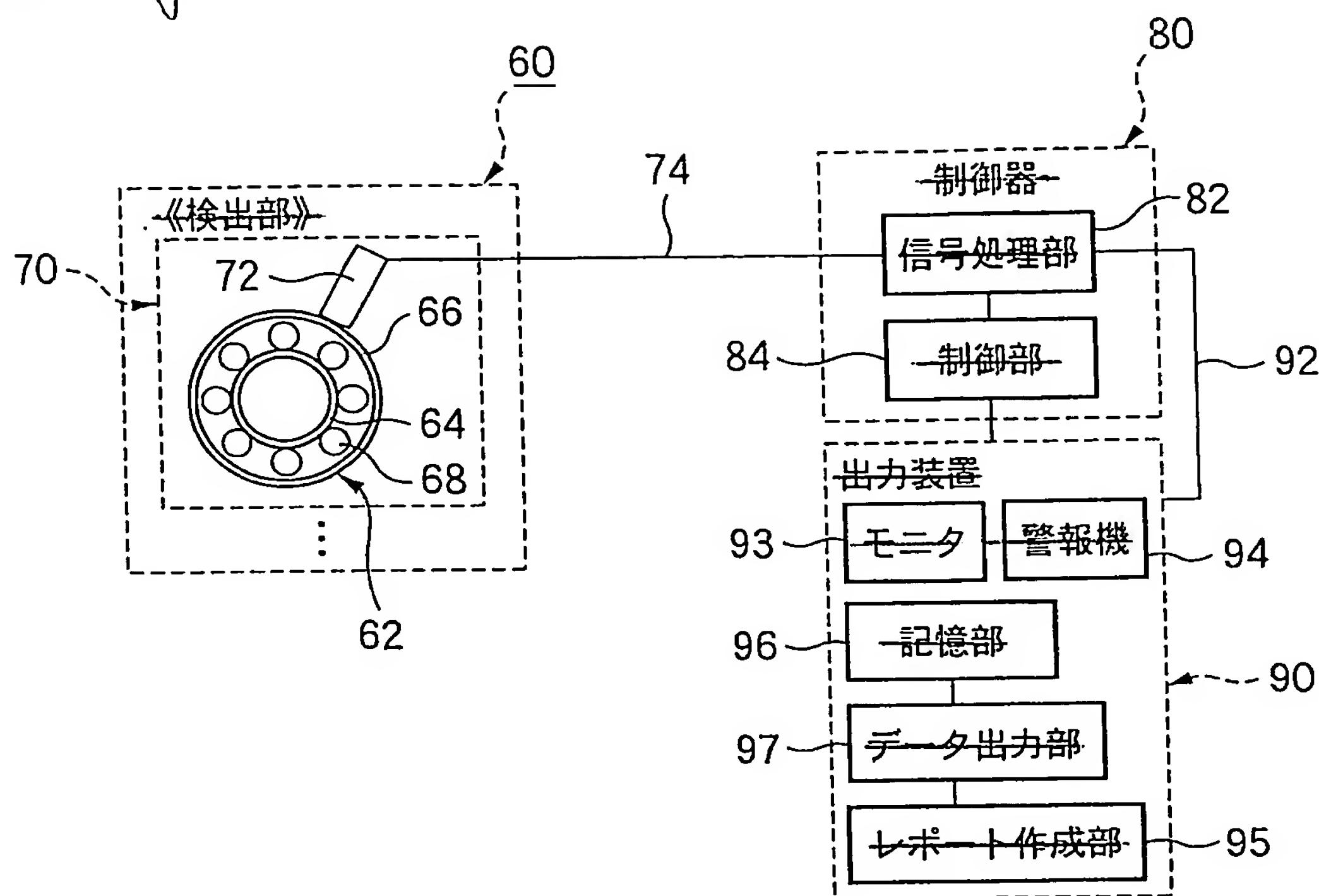
S320  $S_x$ : bearing abnormal

S321  $S_g$ : gear abnormal

S322  $S_r$ : rotating member abnormal

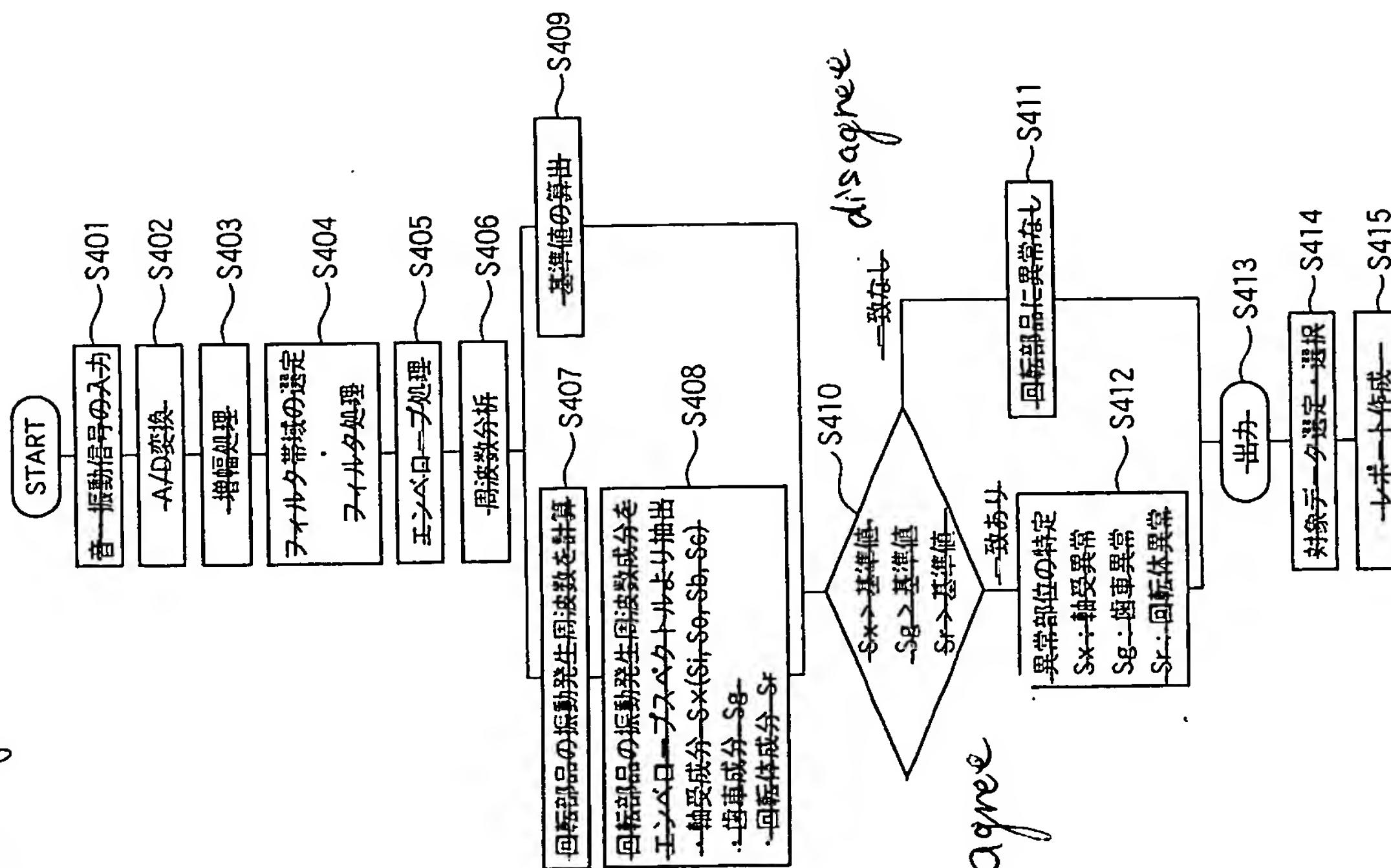
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[図15] Fig. 15



- 60 detecting portion
- 80 controller
- 82 signal processing portion
- 84 controlling portion
- 90 outputting unit
- 93 monitor
- 94 alarm
- 96 storing portion
- 97 data outputting portion
- 95 report forming portion

Fig. 16



[Fig. 16]

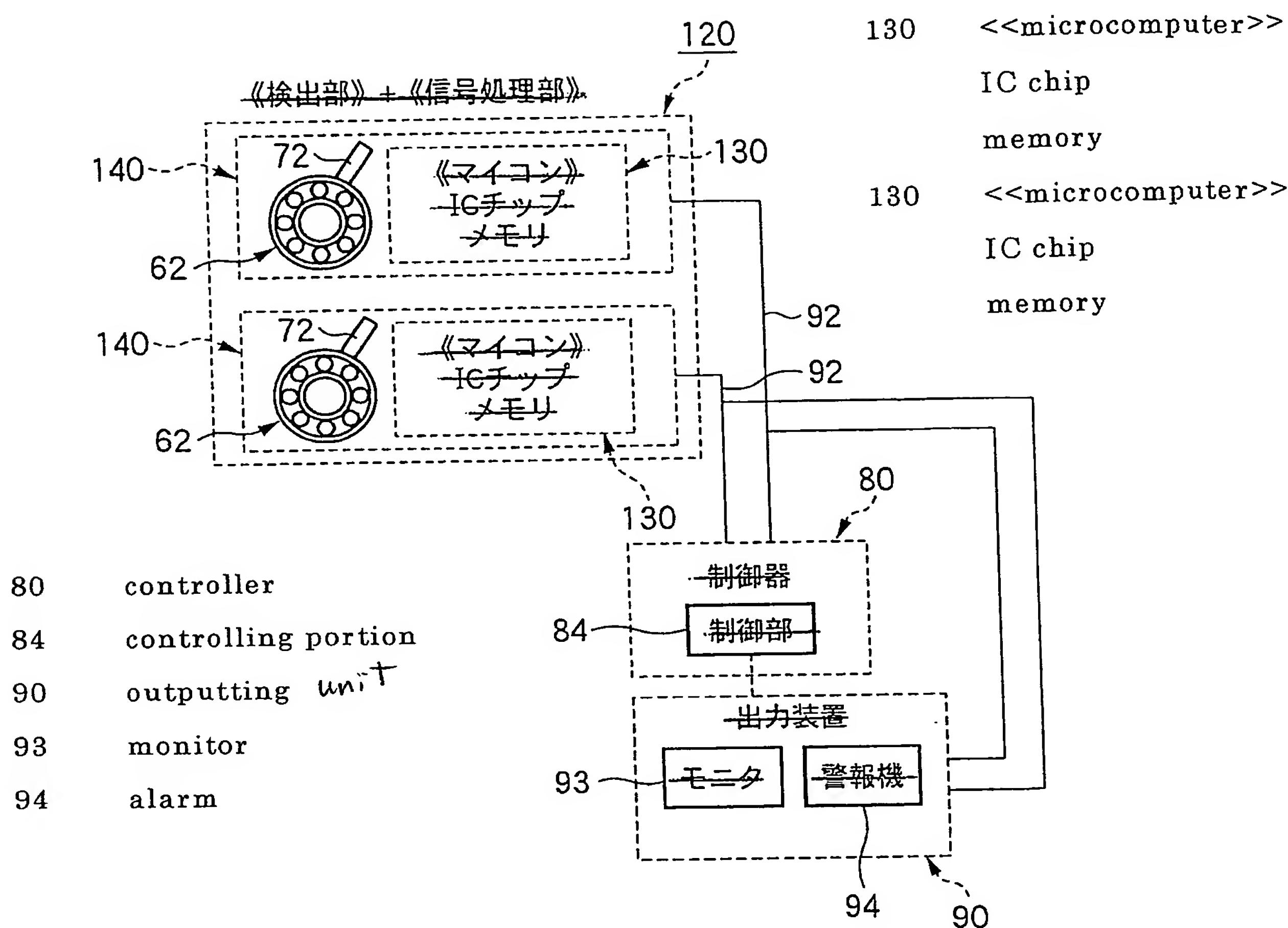
S401	input sound/vibration signal
S402	A/D conversion
S403	amplifying processing
S404	select filter band and filter processing
S405	envelope processing
S406	frequency analysis
S407	calculate vibration generating frequency of rotating part
S408	sample vibration generating frequency component of part from envelope specter
	· bearing component $S_x$ ( $S_i$ , $S_o$ , $S_b$ , $S_c$ )
	· gear component $S_g$
	· rotating member component $S_r$
S409	calculate reference value
S410	$S_x >$ reference value
	$S_g >$ reference value
	$S_r >$ reference value
S411	rotating part is not abnormal
S412	specify abnormal portion
	$S_x$ : bearing abnormal
	$S_g$ : gear abnormal
	$S_r$ : rotating member abnormal
S413	output
S414	select object data
S415	form report

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Fig. 17

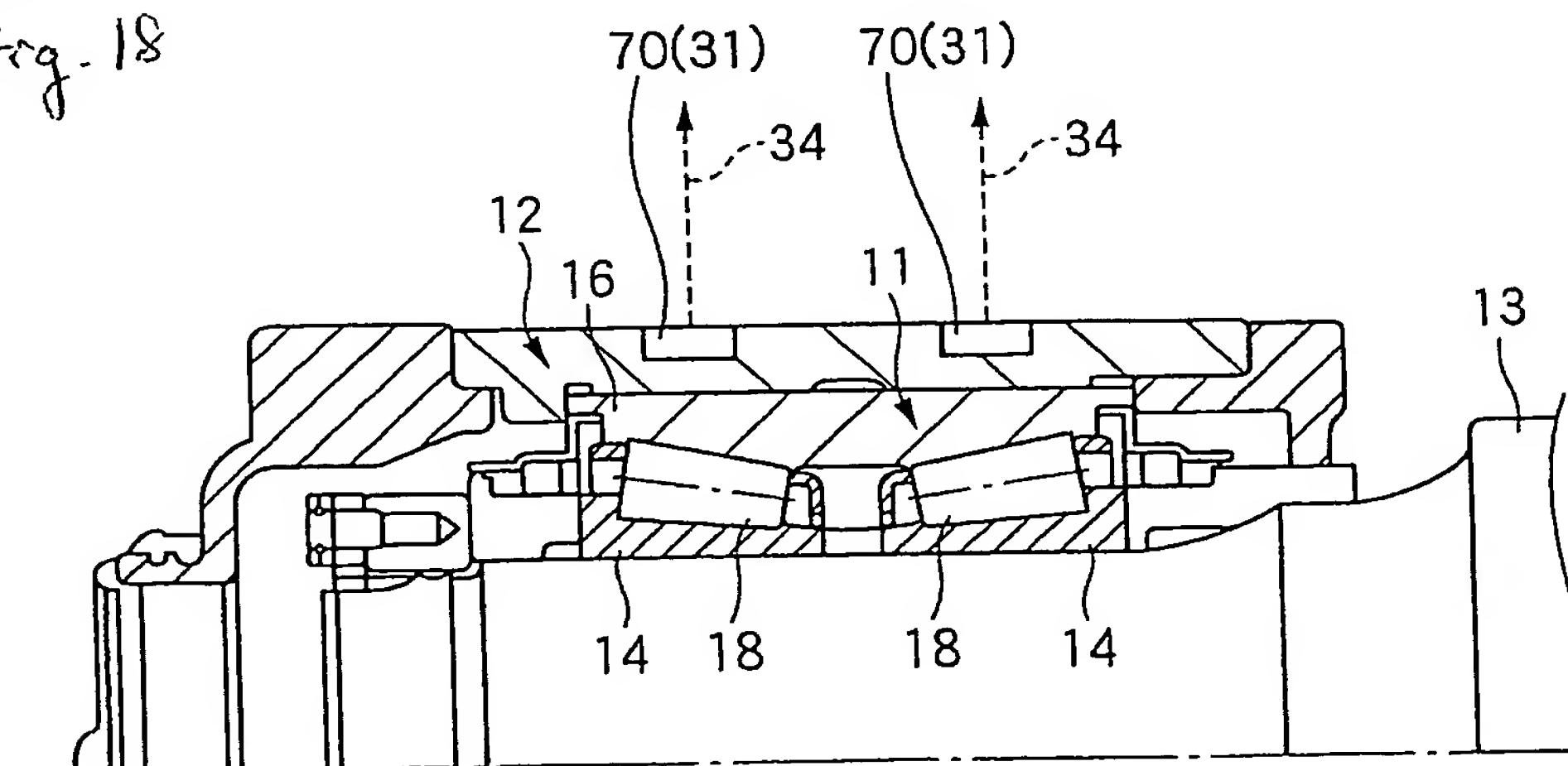
[図17]

120 detecting portion +  
 signal processing portion

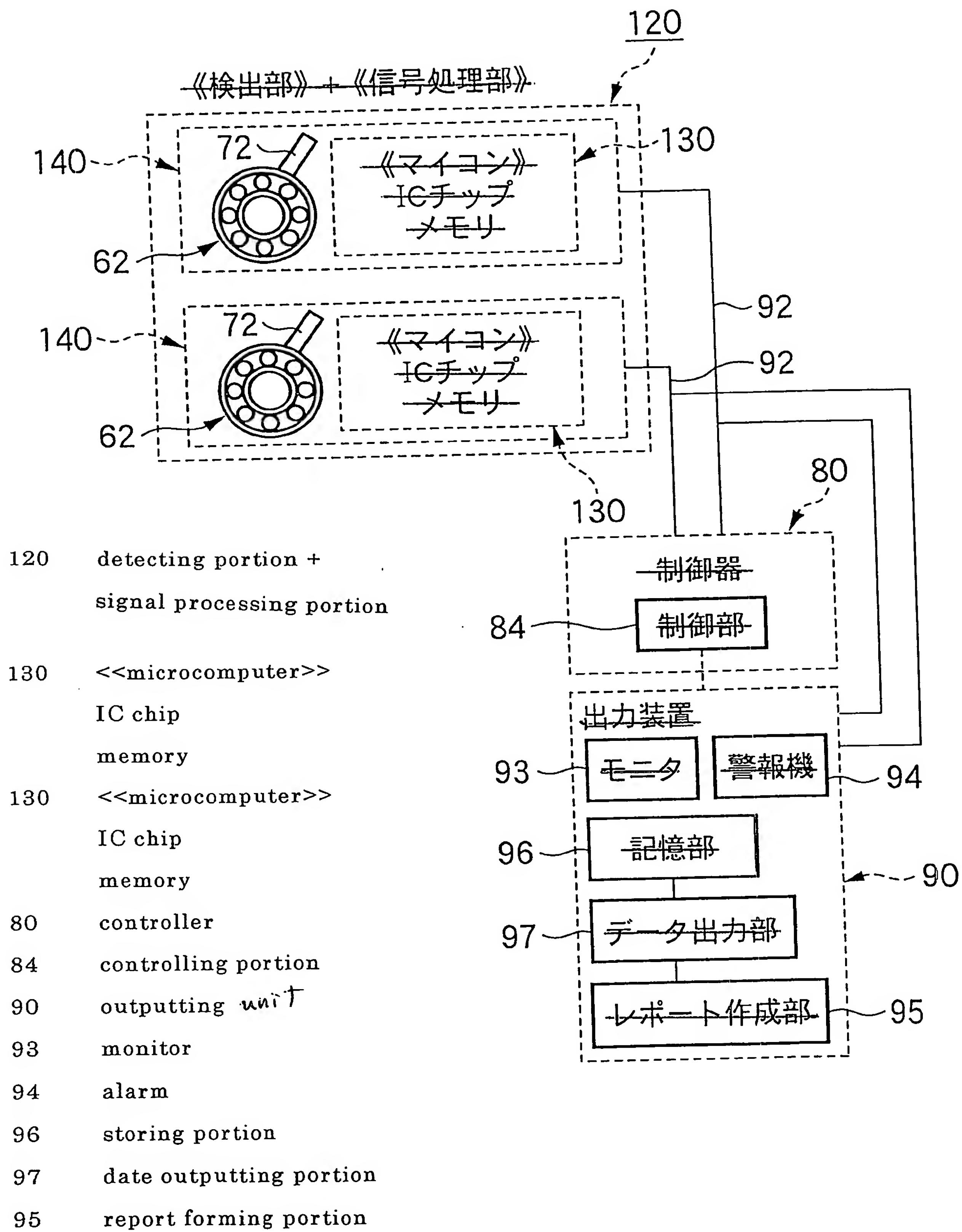


[図18]

Fig. 18



[図19] Fig. 19



[図20] Fig. 20

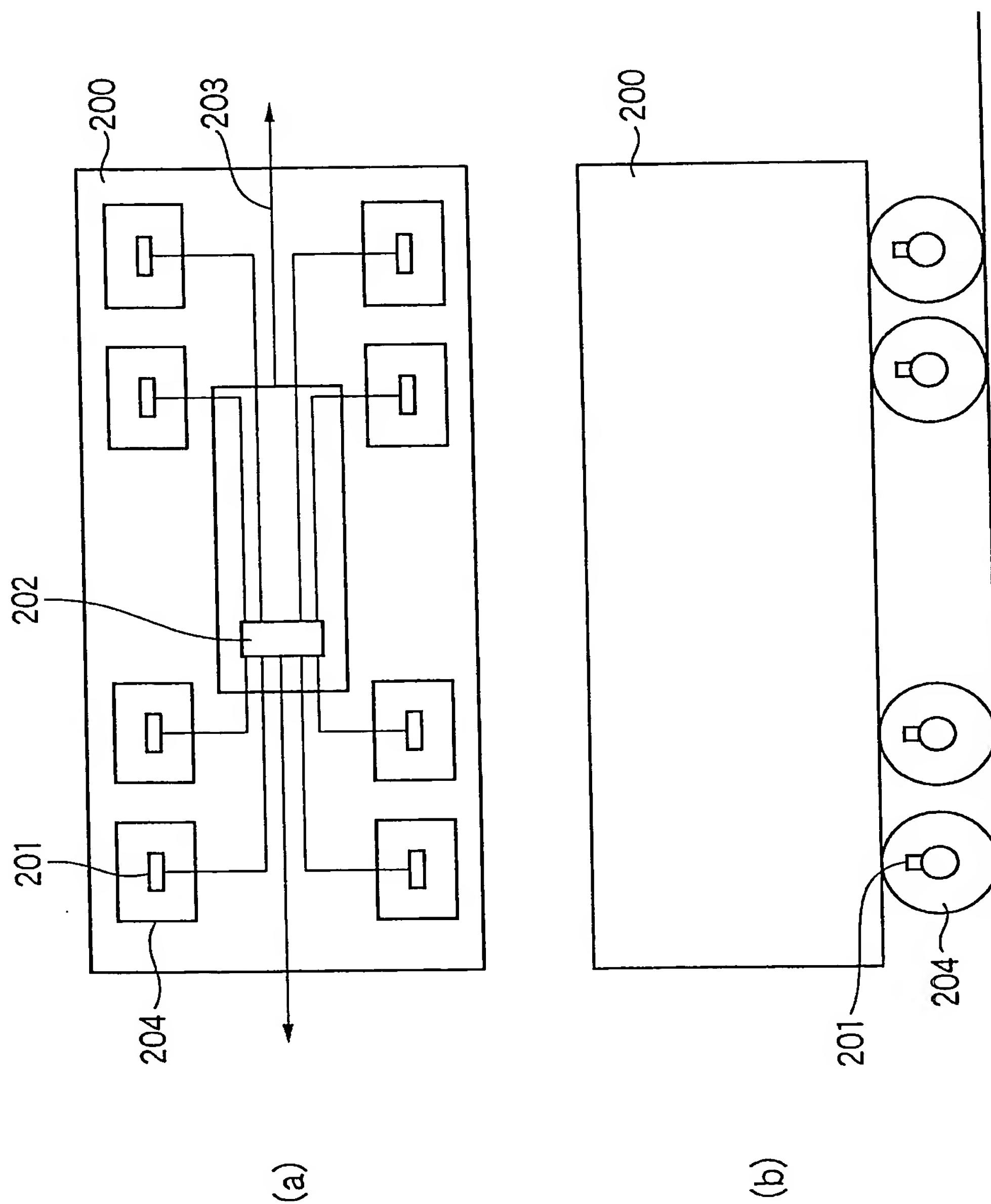


図21  
21

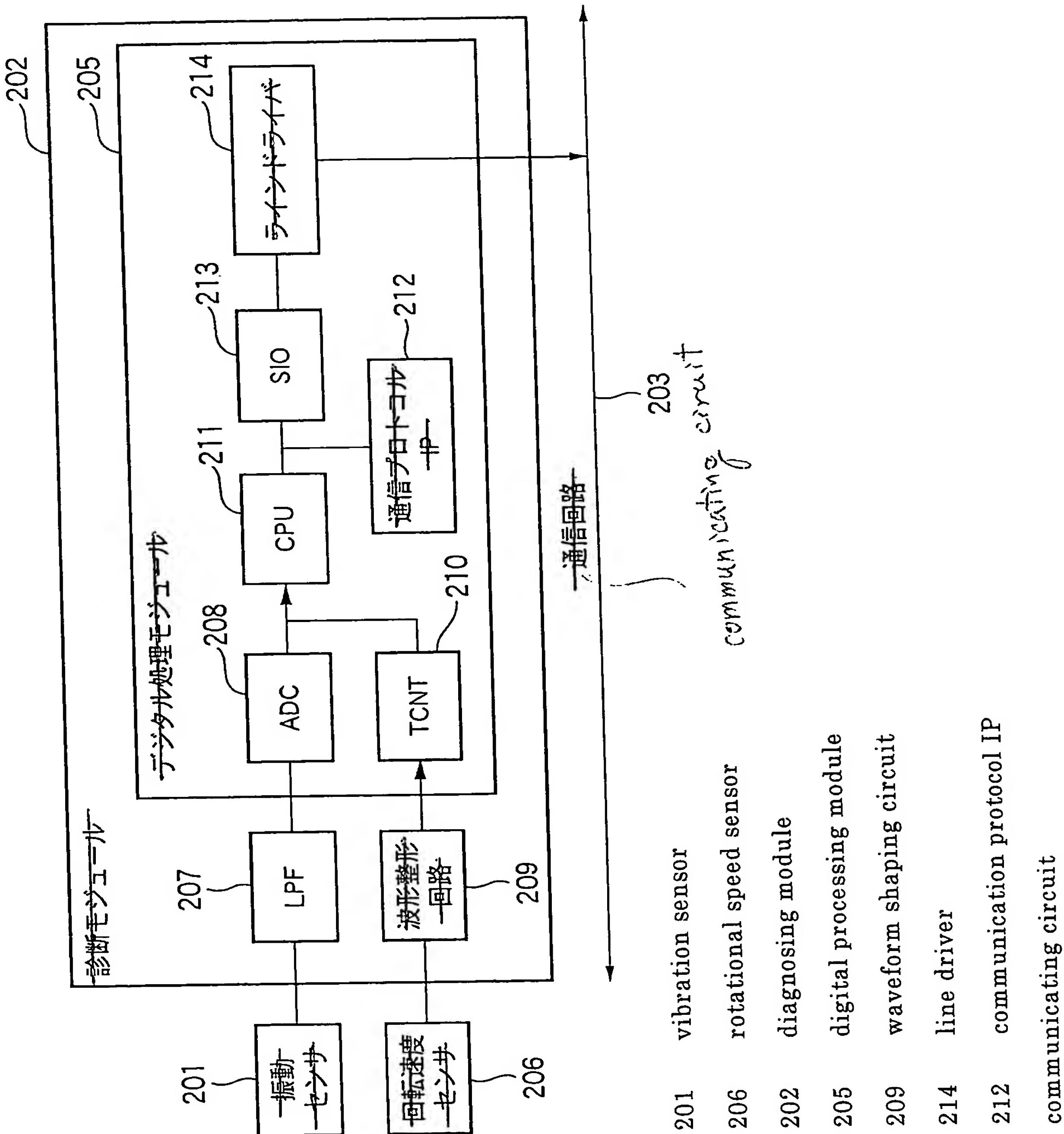
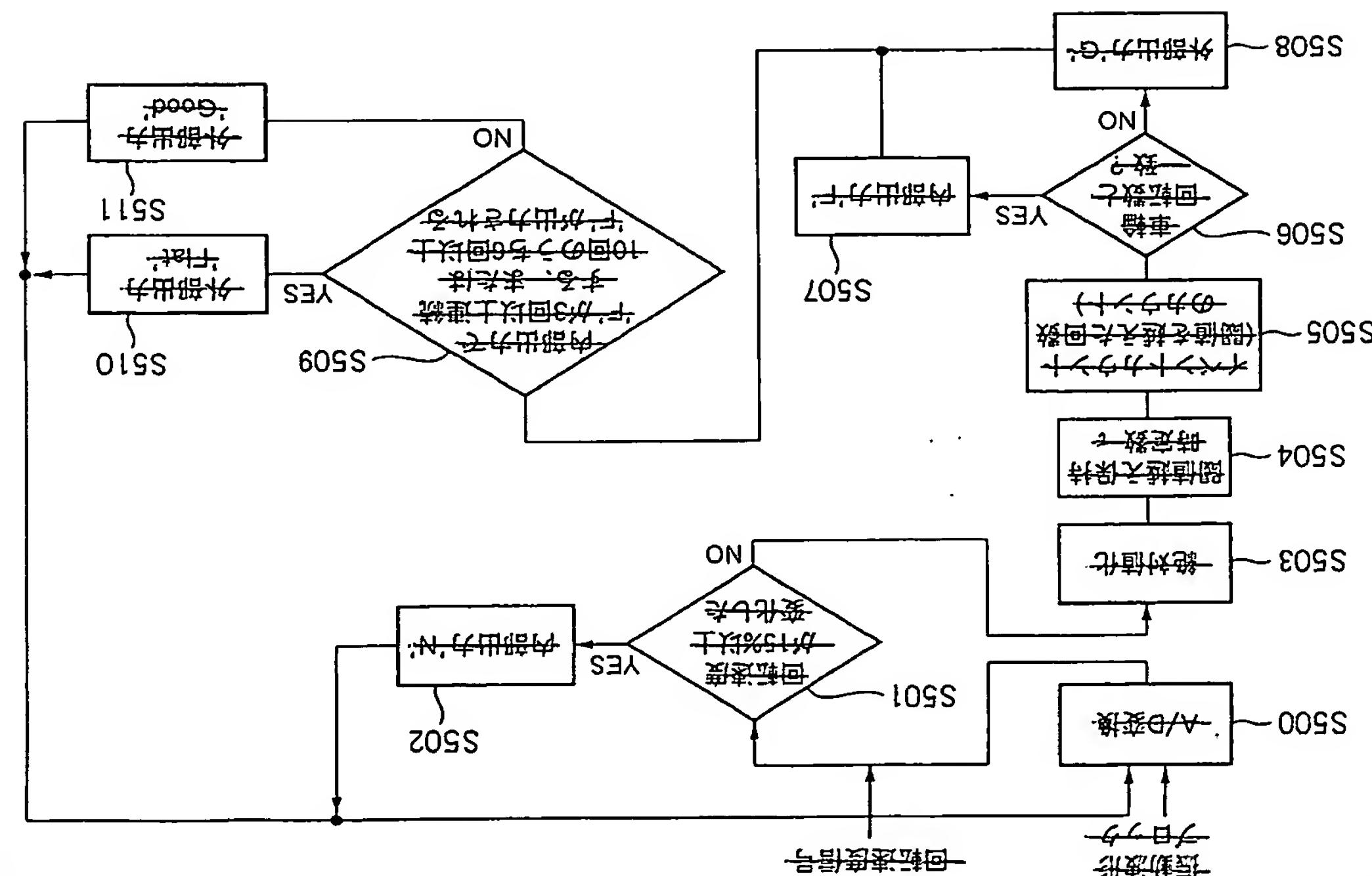


Fig. 22



[Fig. 22]

S500 A/D conversion

S503 form absolute value

S504 hold to exceed threshold, time constant  $r$

S505 event count (count of number of times of exceeding threshold)

S506 coincide with wheel rotational number?

S507 internal output "F"

S508 external output "G"

S509 rotational speed changed by 15 % or more?

S510 internal output "N"

S511 external output "Good"

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Fig. 23 A

[図23]

(a)

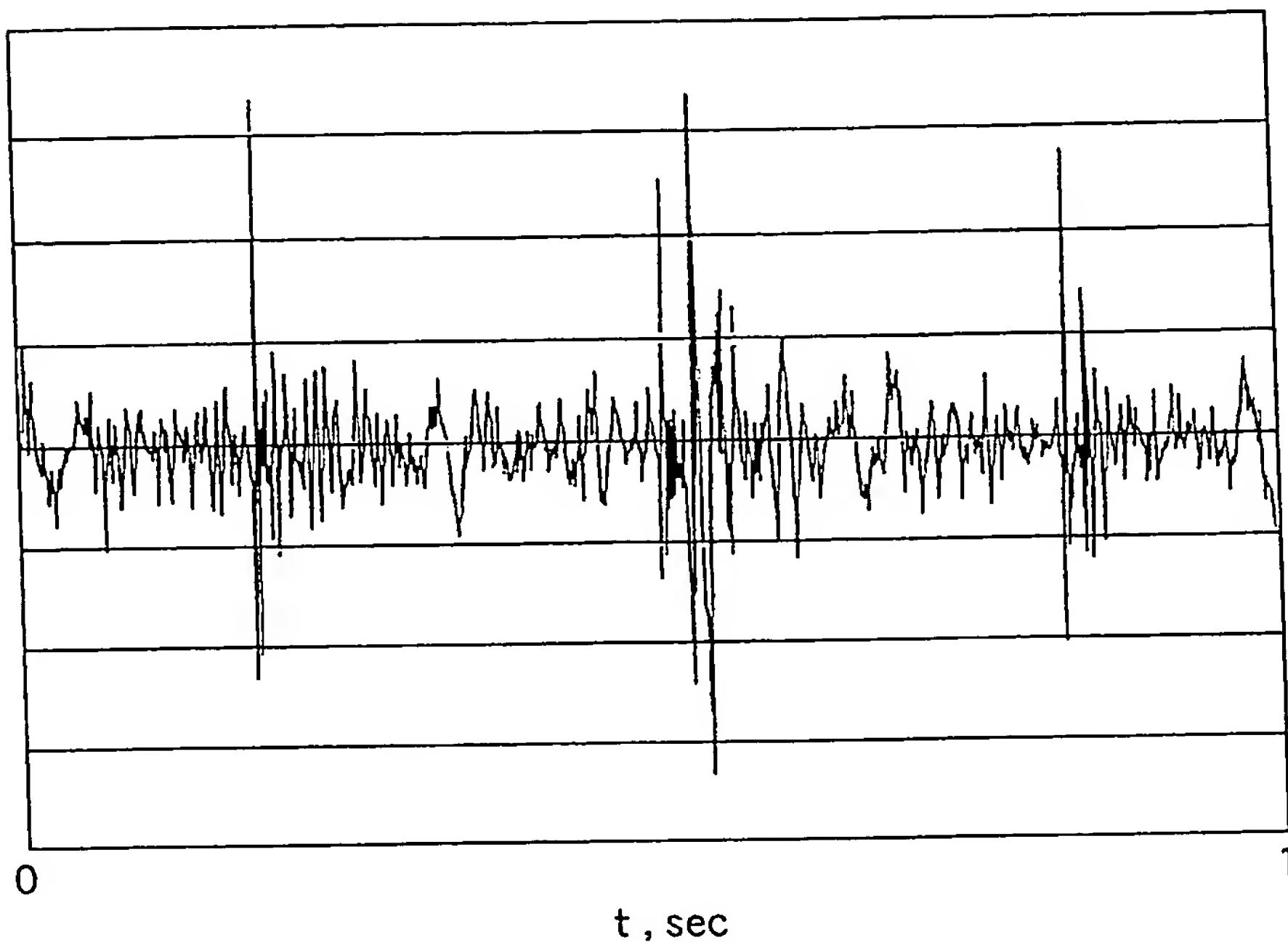


Fig. 23 B

(b)

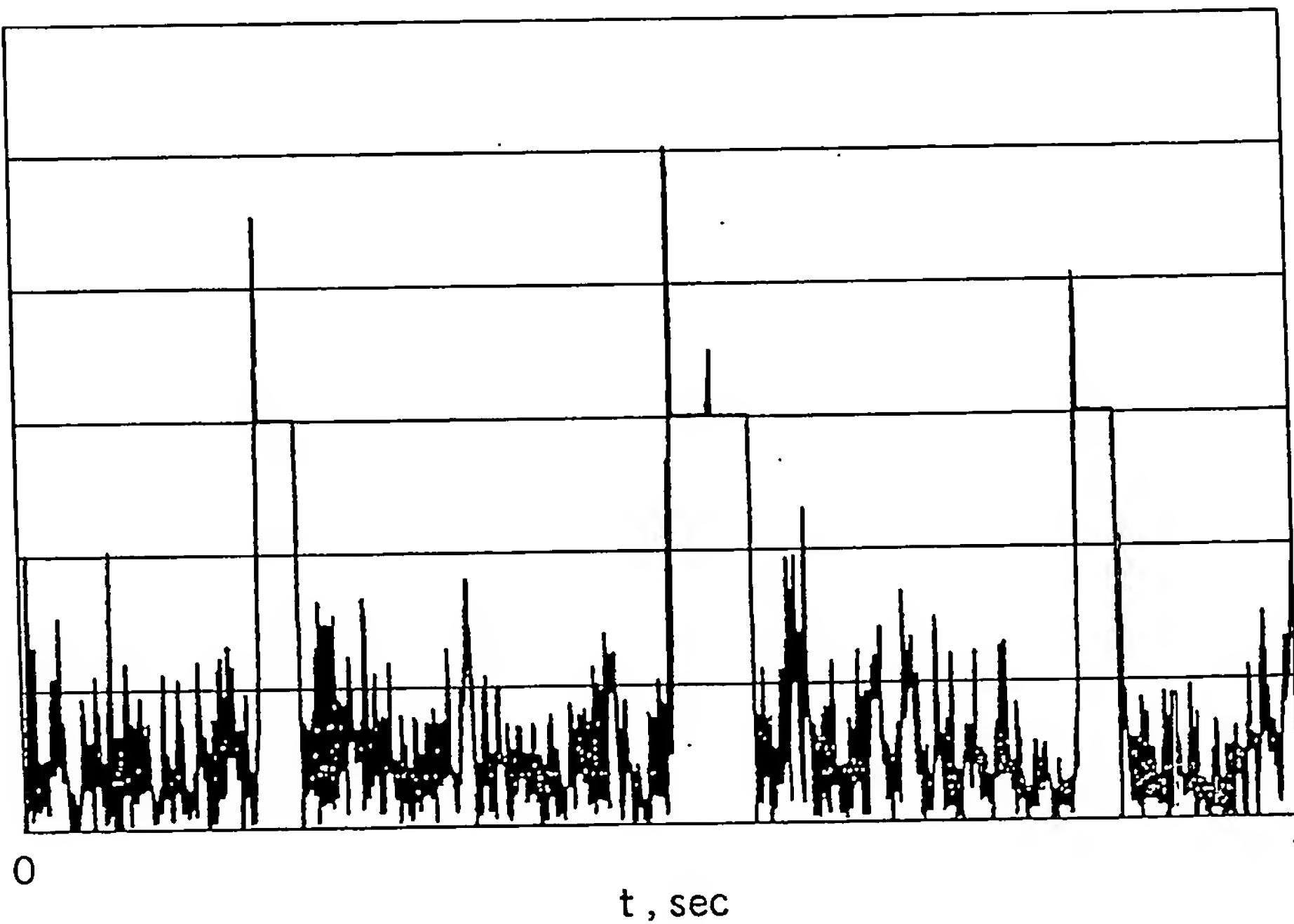
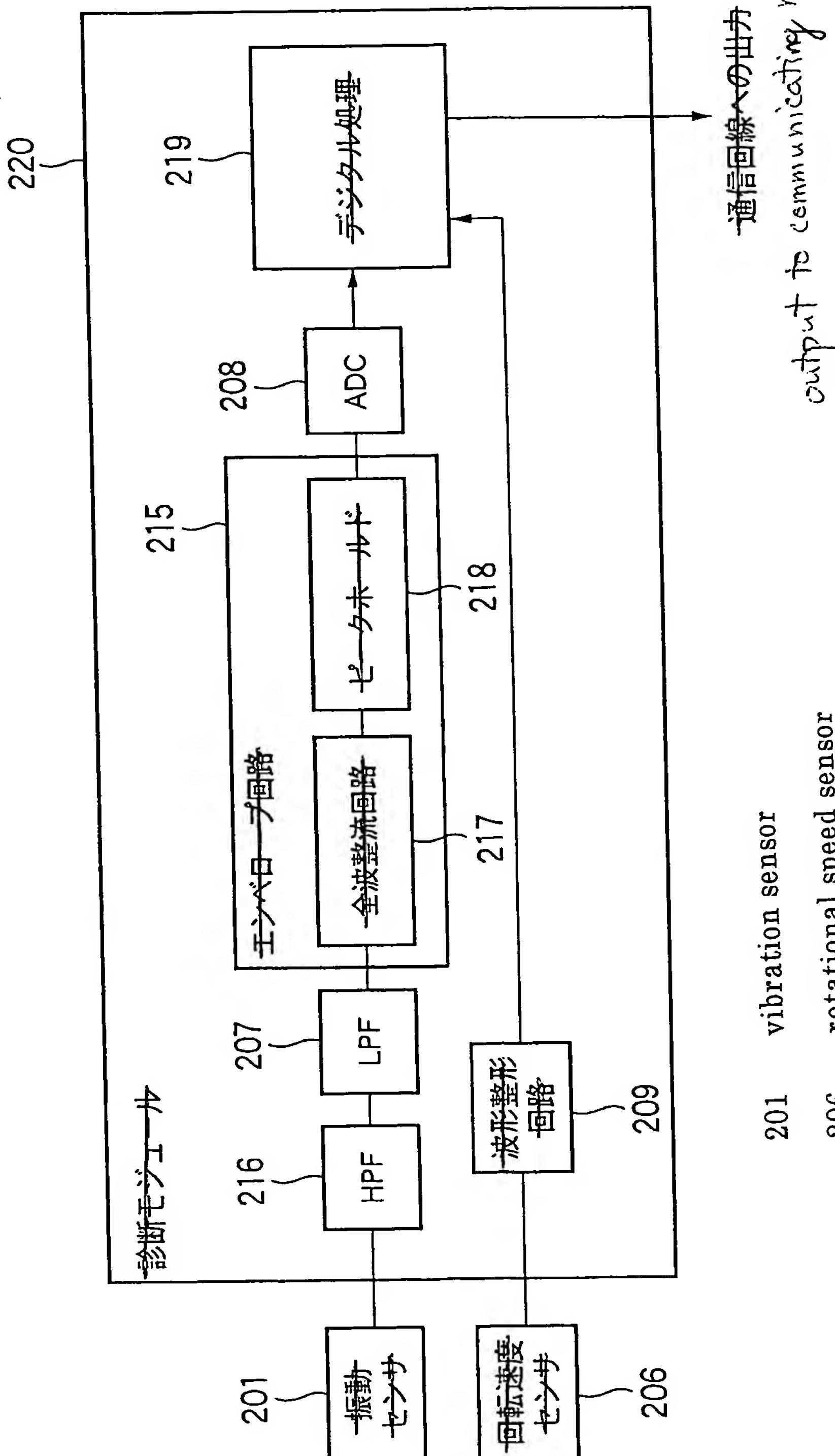


Fig. 24

[図24]



- 201 vibration sensor
- 206 rotational speed sensor
- 220 diagnosing module
- 209 waveform shaping circuit
- 215 envelope circuit
- 217 full wave rectified circuit
- 218 peak hold
- 219 digital processing

[図25]

Fig-25

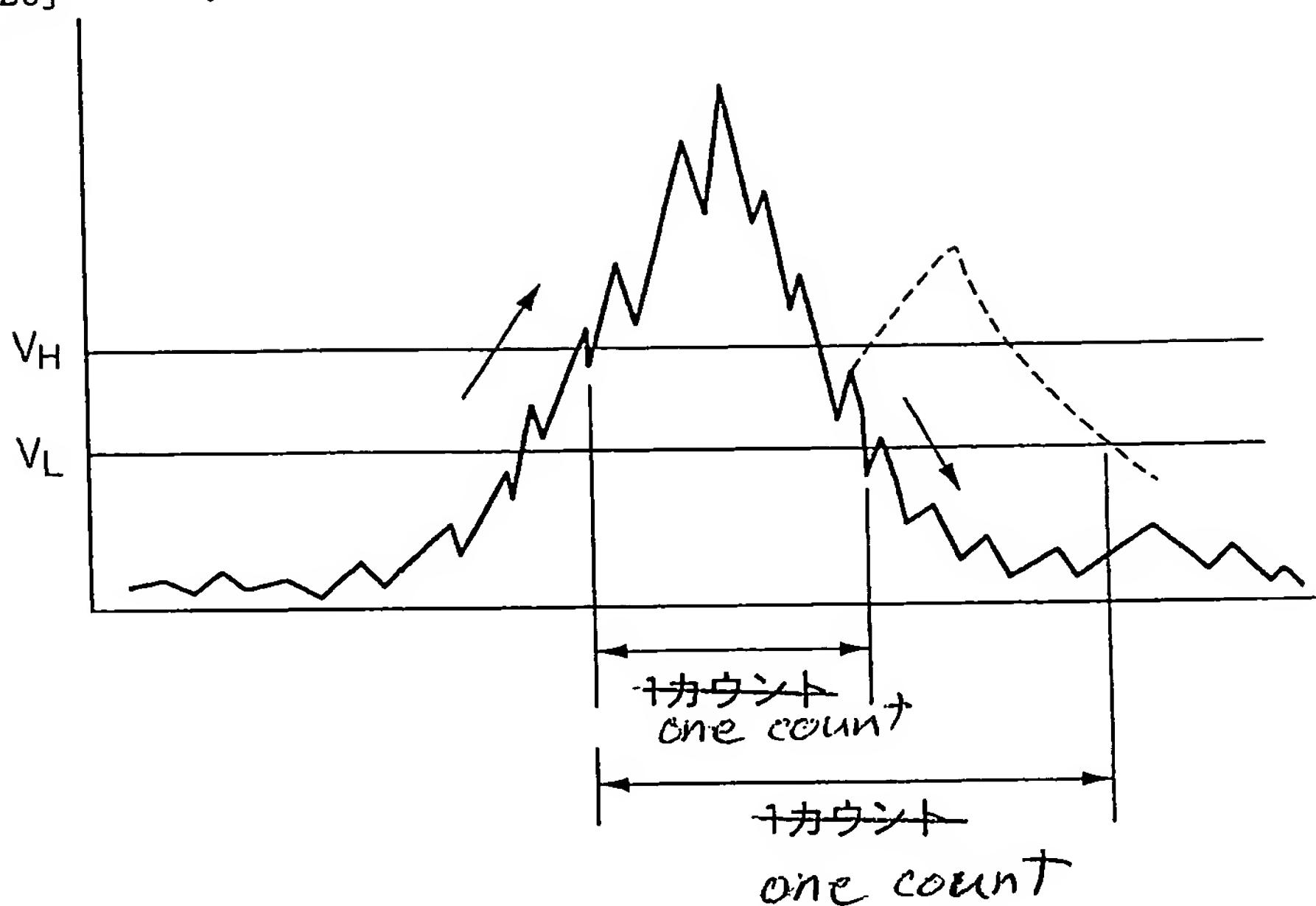
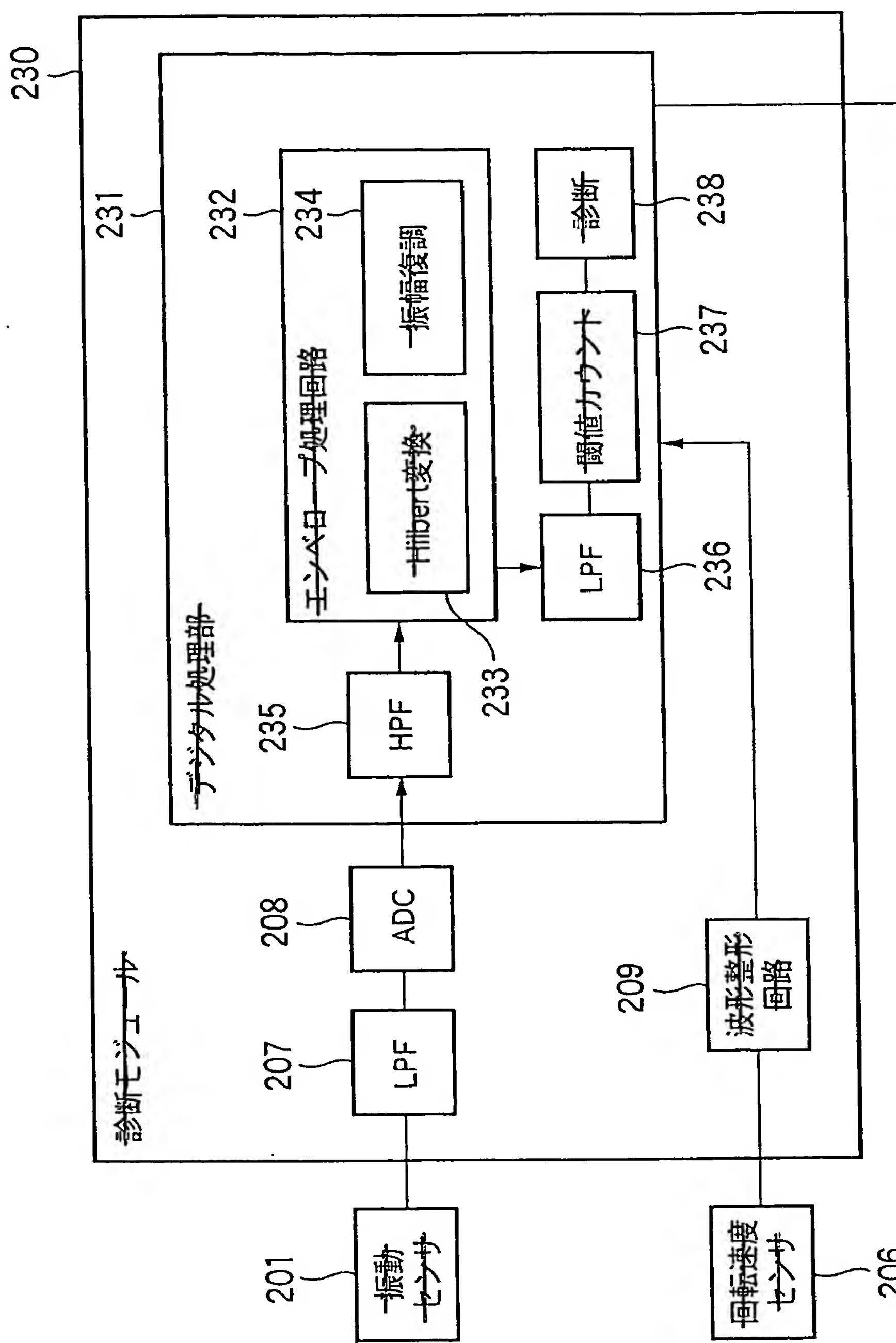


図26  
Fig. 26

201 vibration sensor  
 206 rotational speed sensor  
 209 waveform shaping circuit  
 230 diagnosing module  
 231 digital processing portion

232 envelop processing circuit  
 233 Hilbert conversion  
 234 decode amplitude  
 235 count threshold  
 236 count threshold  
 237 count threshold  
 238 diagnose

206 output to communication network

[図27]

Fig. 27A

-(a)-

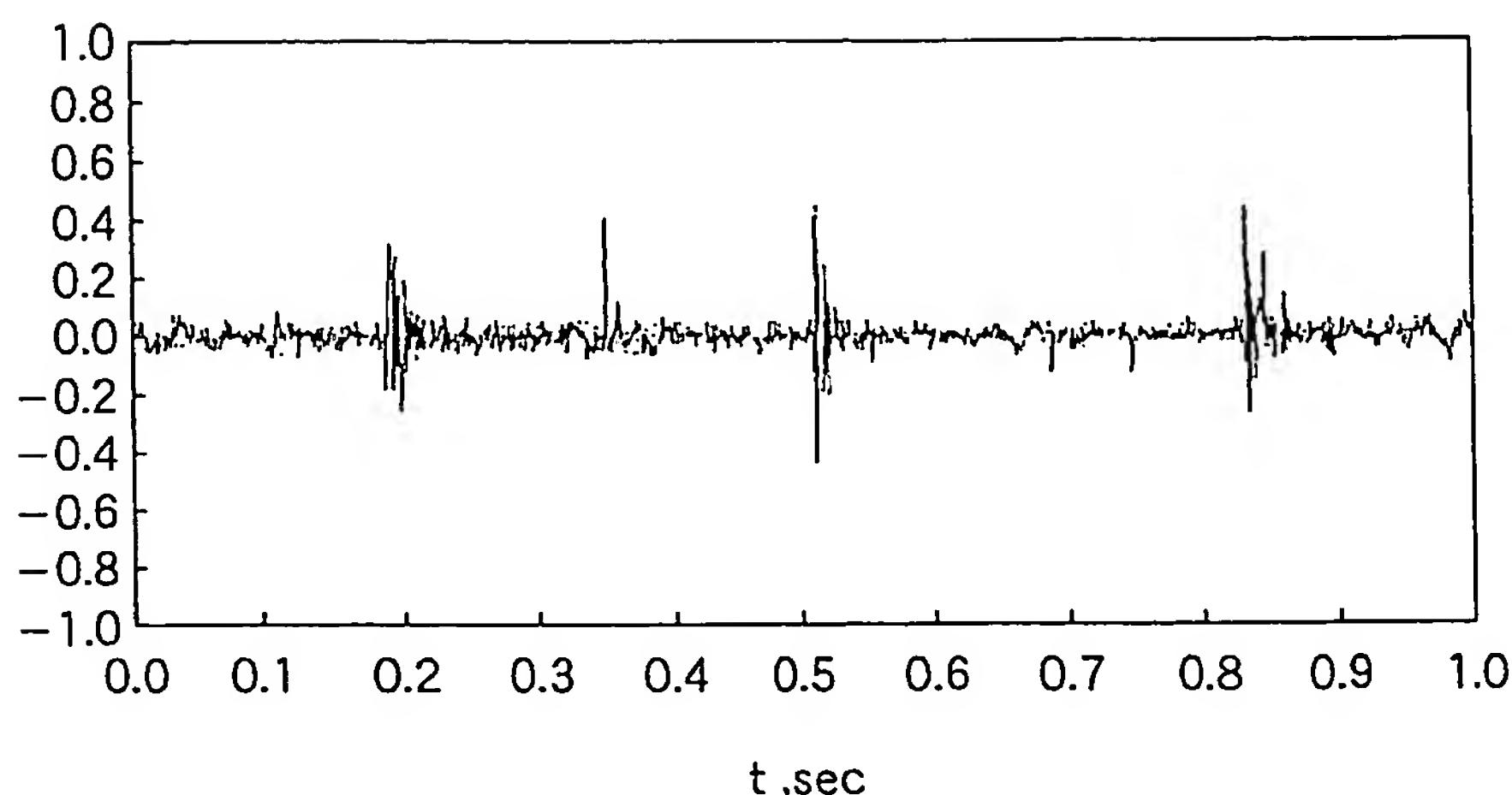
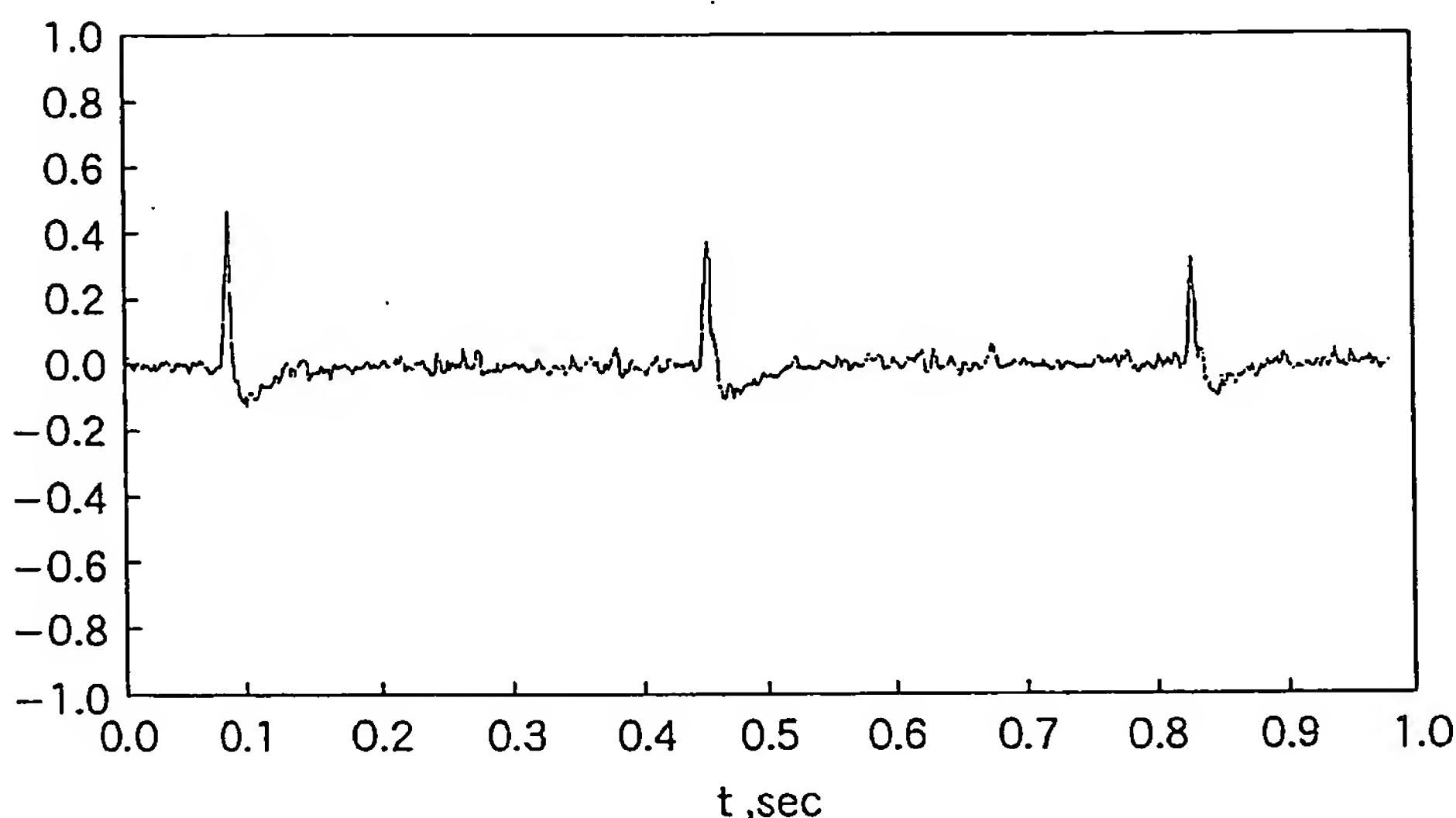


Fig. 27B

-(b)-



一秒間に3回の衝撃波が発生している  
 shock waves are generated by three times in one second.

Fig. 28

[図28]

damage component of outer ring

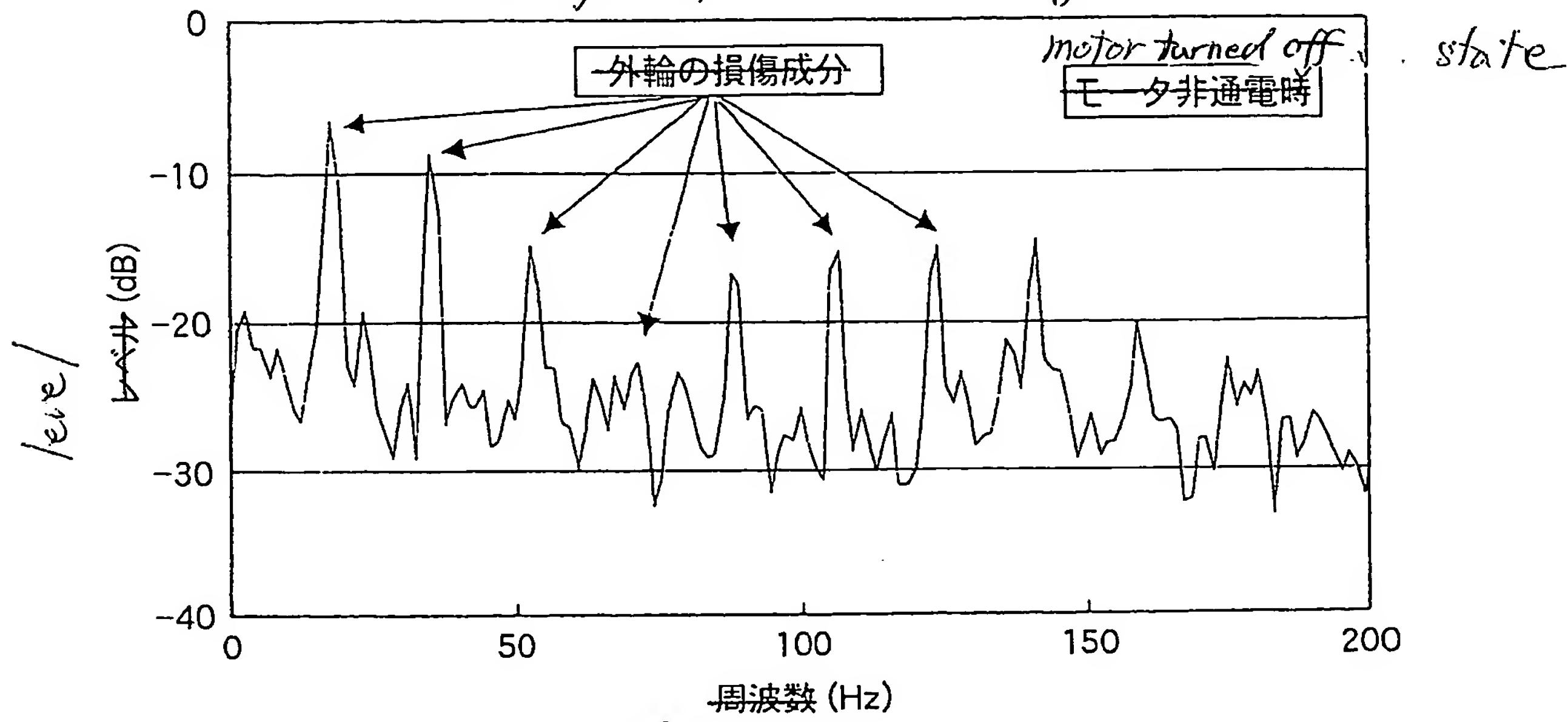
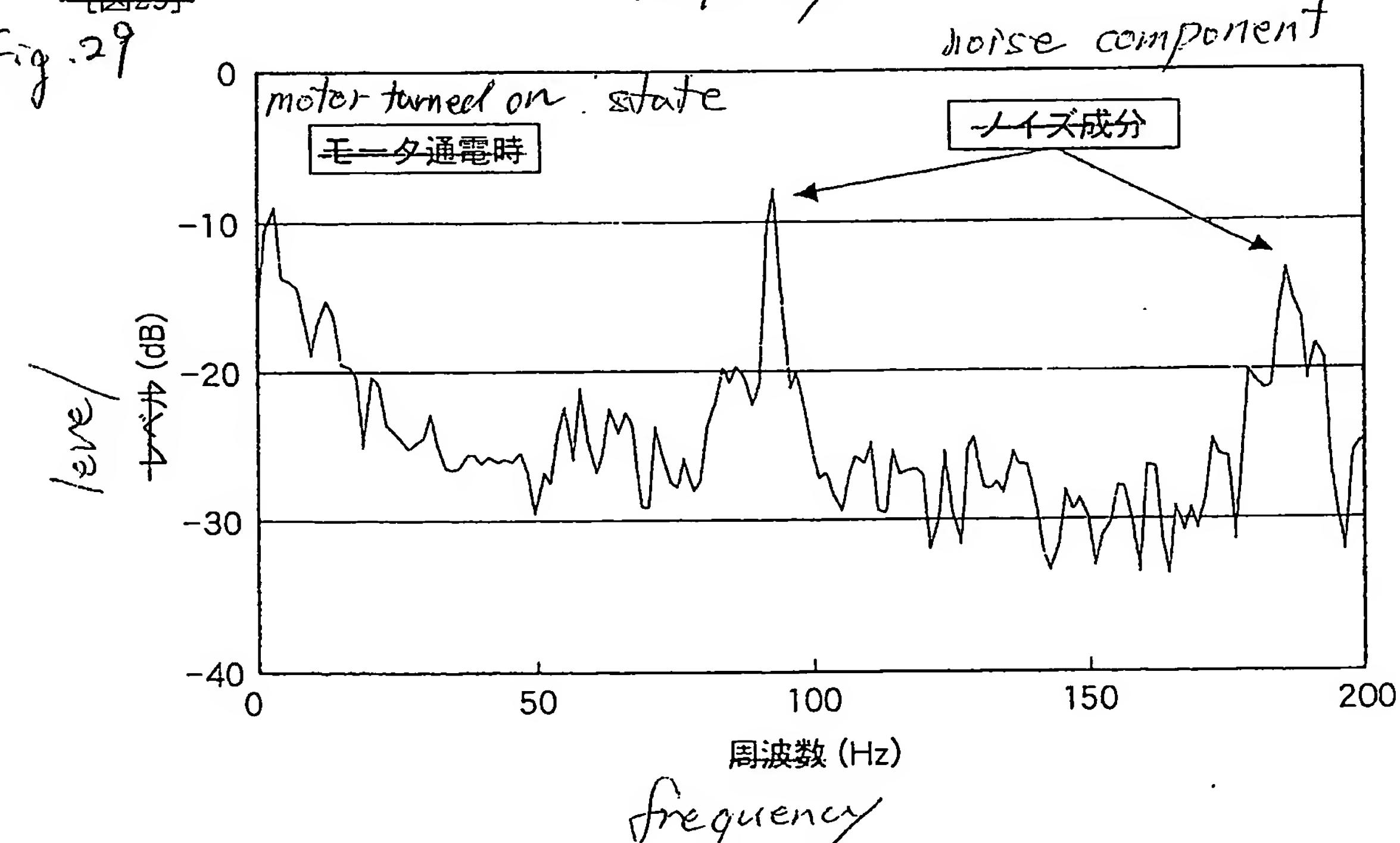


Fig. 29

[図29]

frequency

noise component



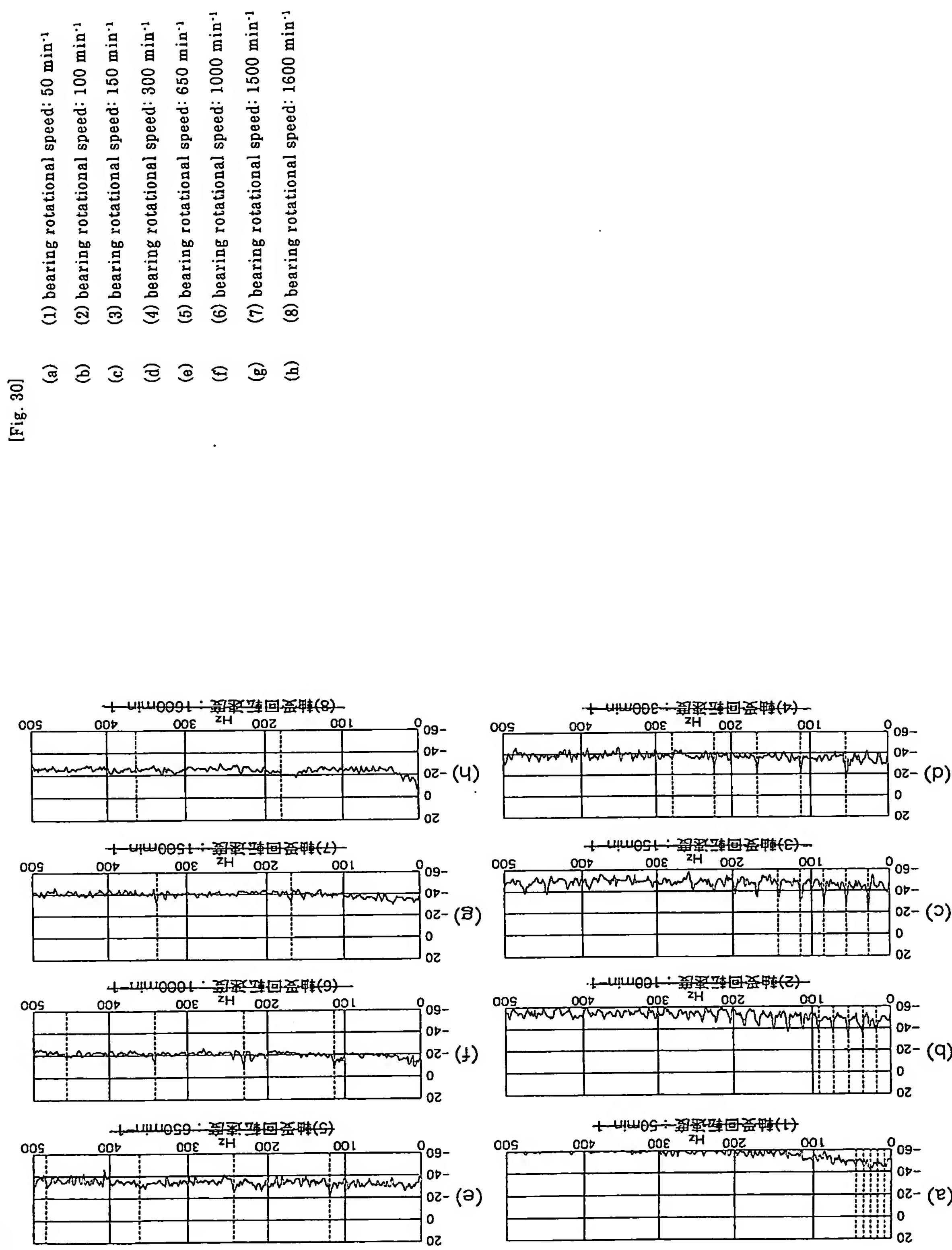


Fig. 3)

-[図31]-

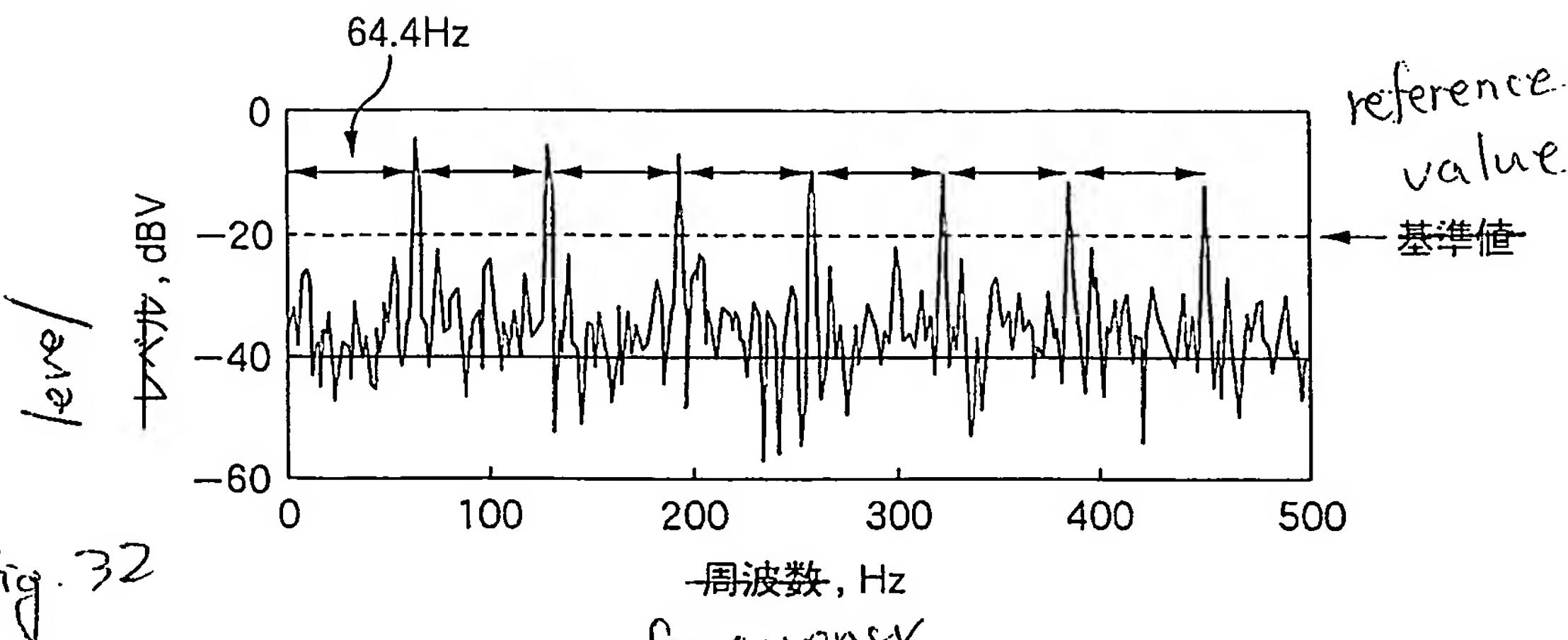


Fig. 32

-[図32]-

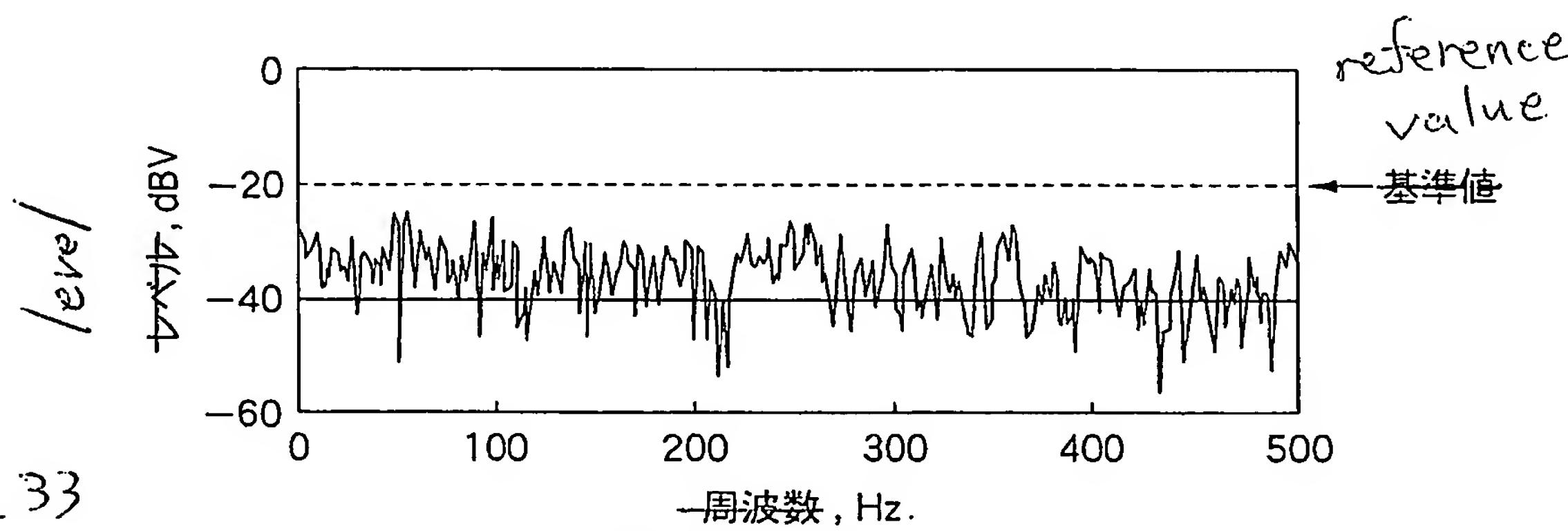


Fig. 33

-[図33]-

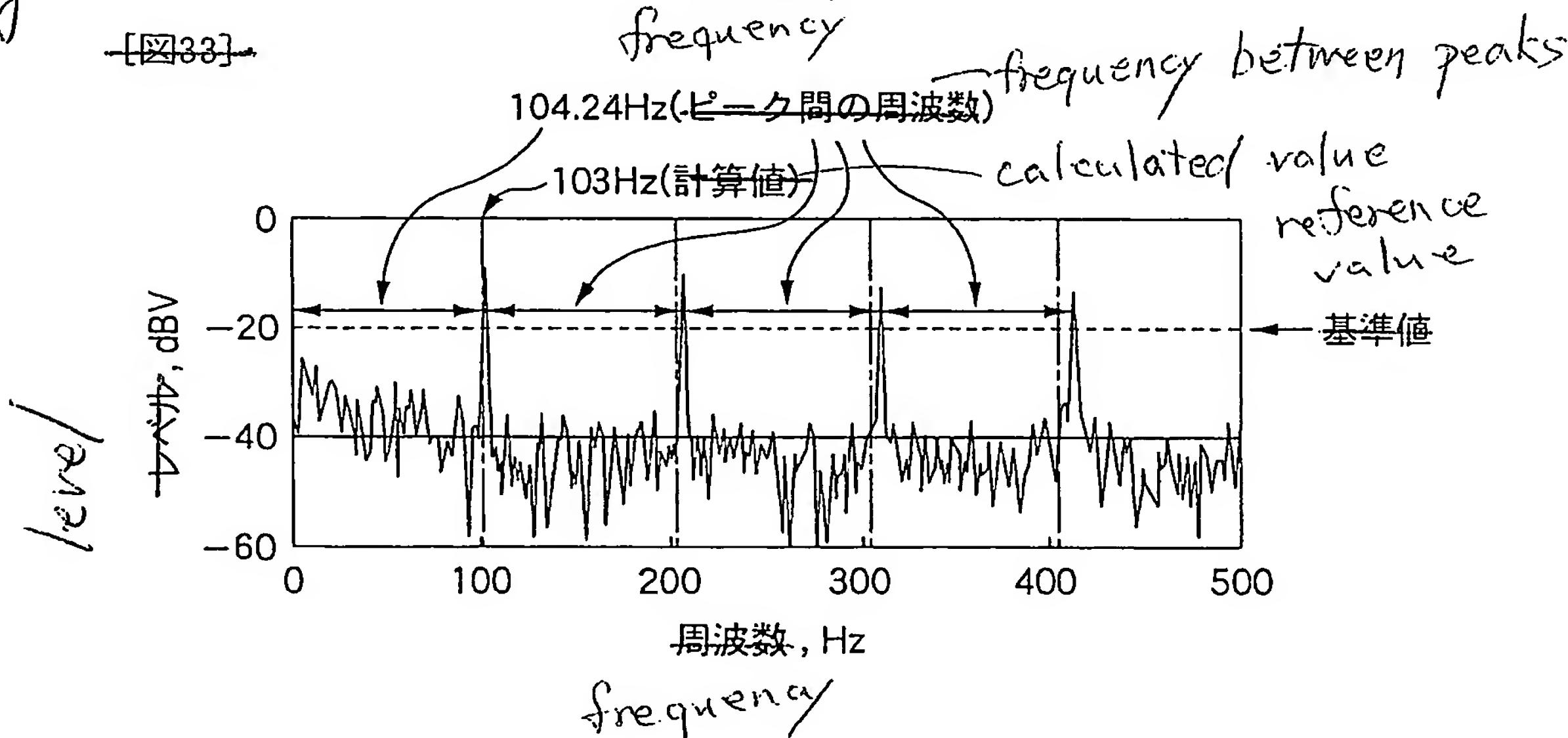
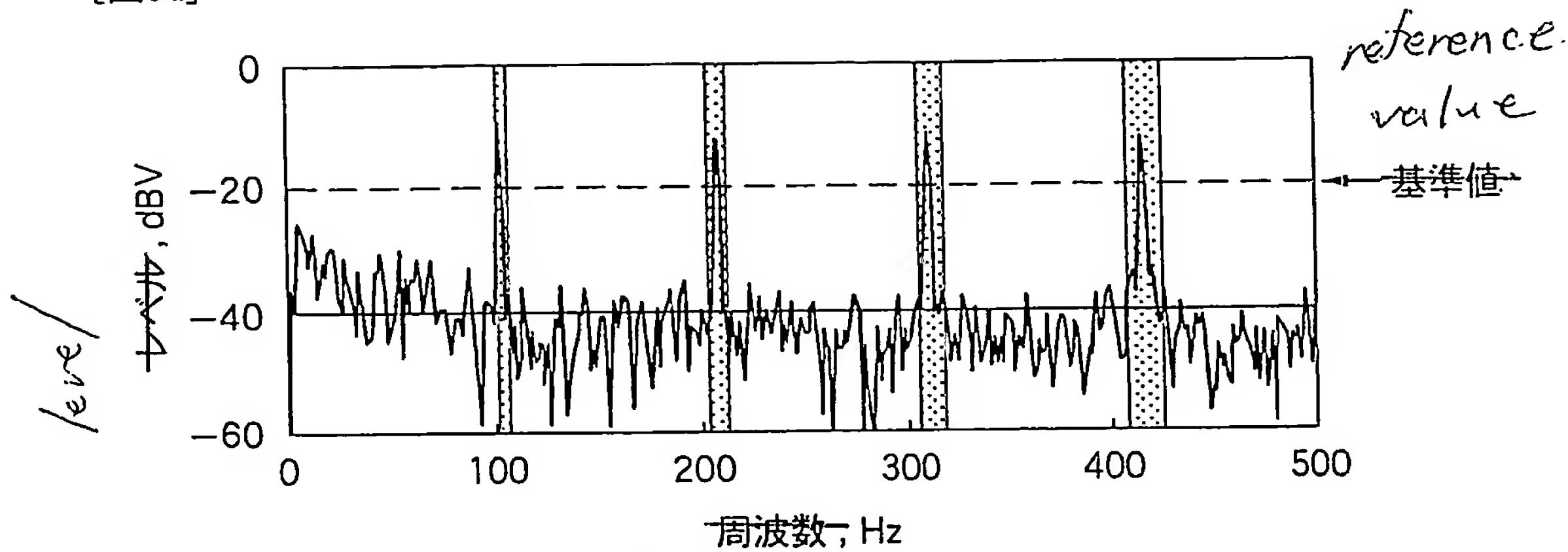


Fig. 34

[図34]



[図35] Fig. 35

frequency

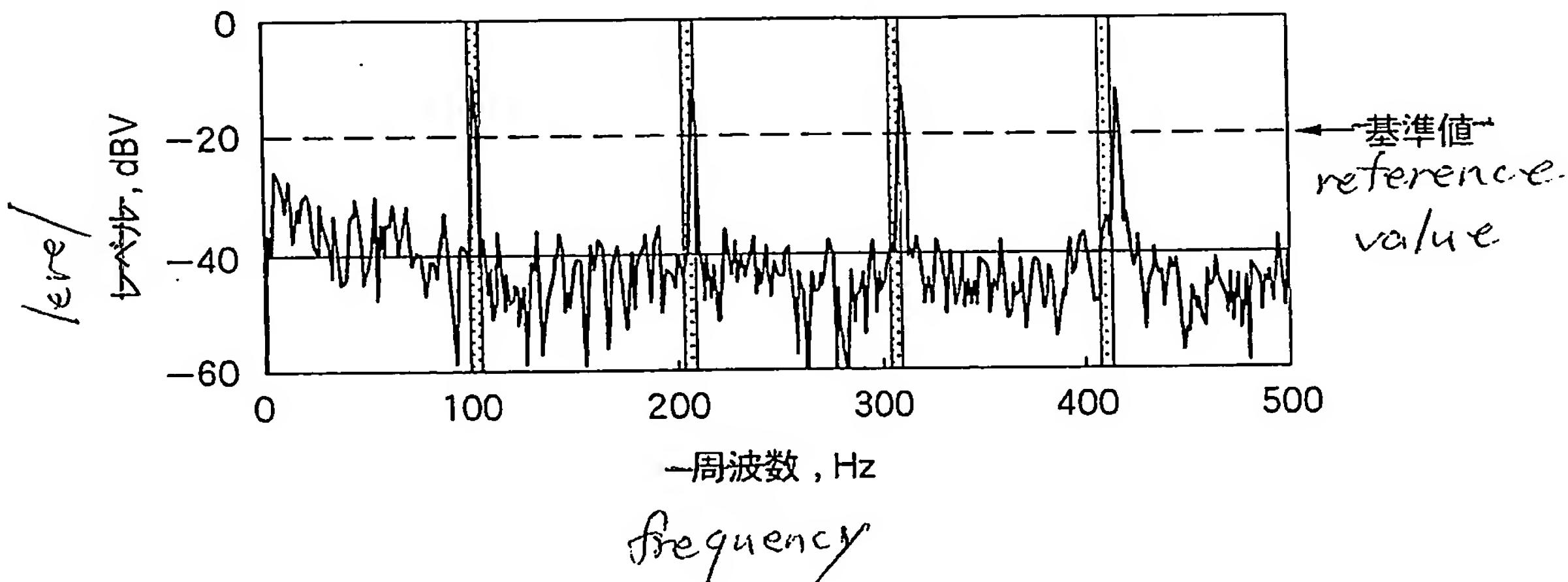
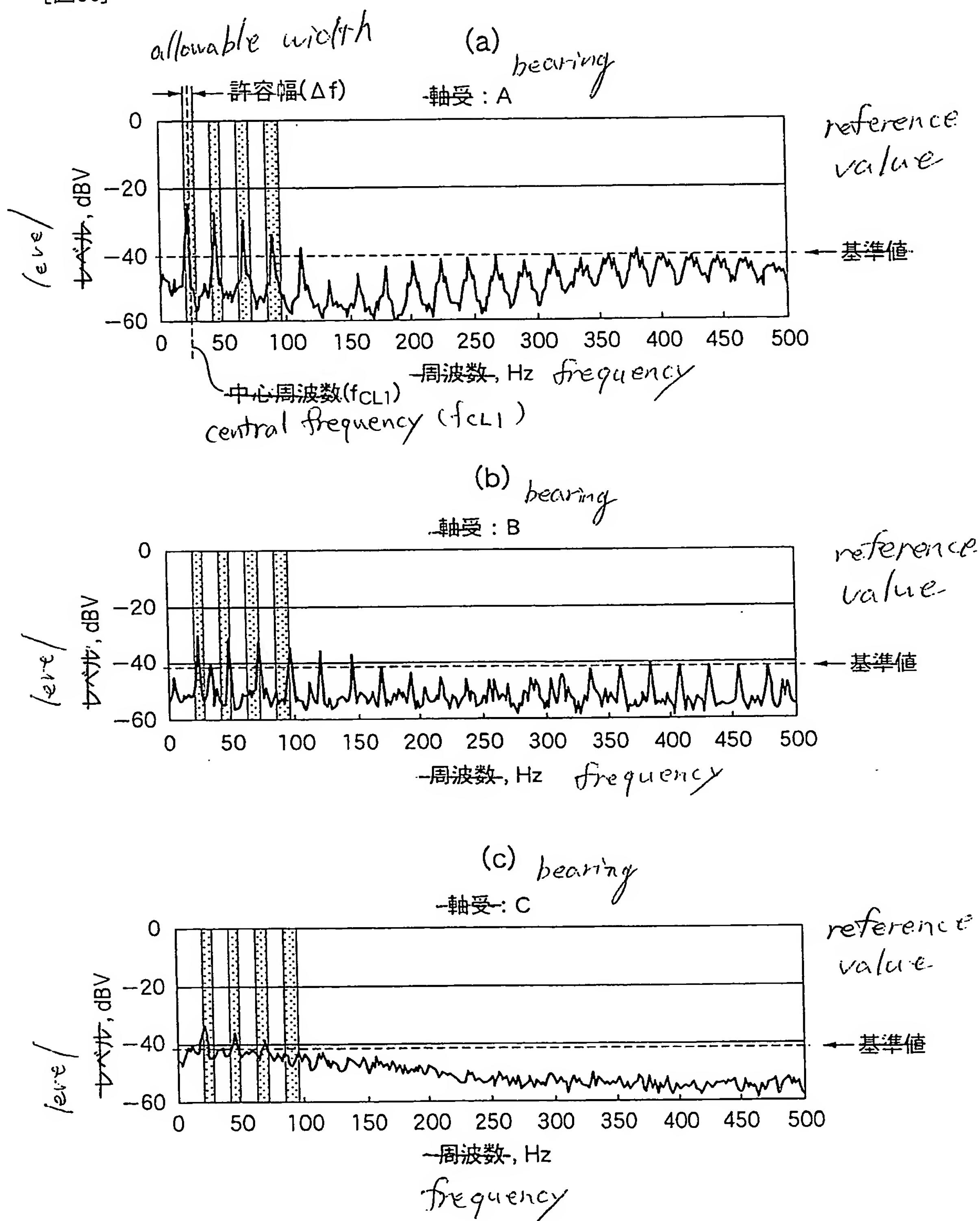
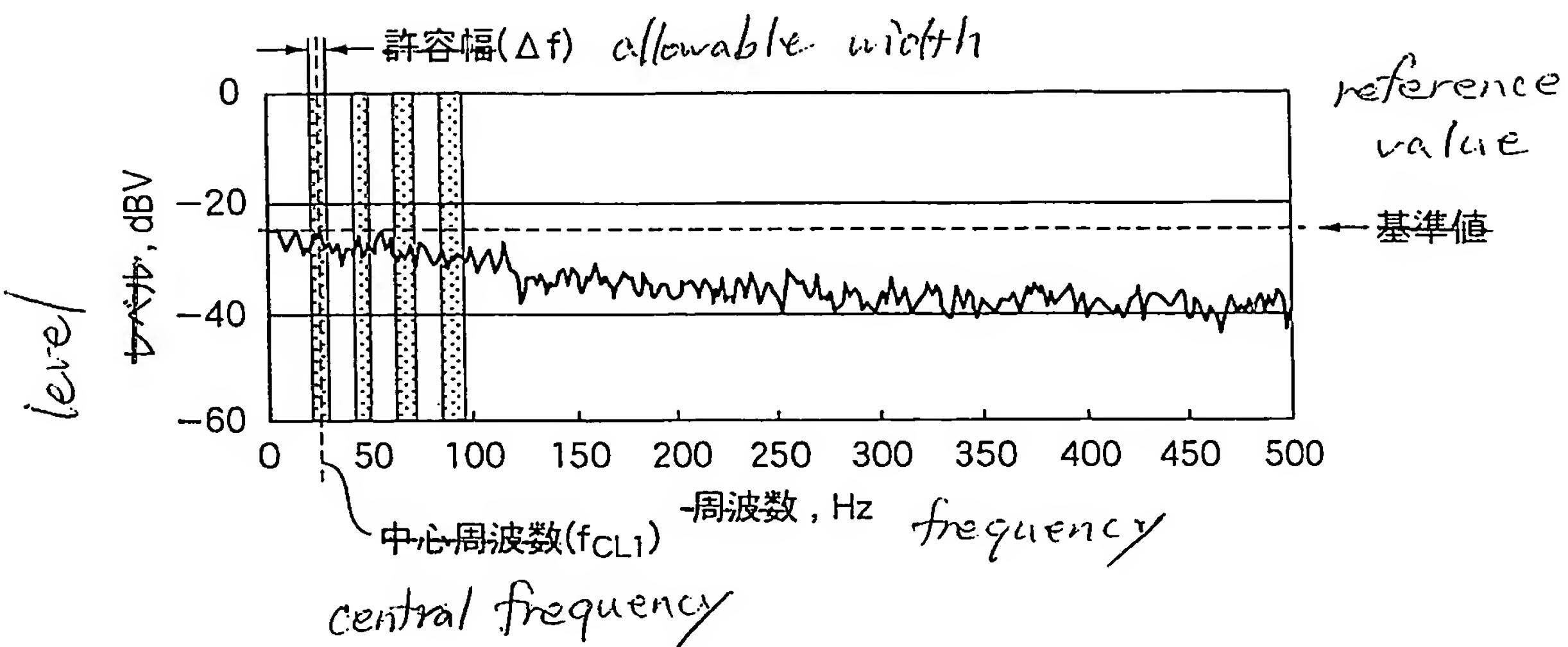


Fig. 36

[Fig.36]



[図37] *normal bearing*  
 (same specifications as bearing A)  
 Fig. 37 正常軸受(軸受Aと同一諸元)



[図38] Fig. 38

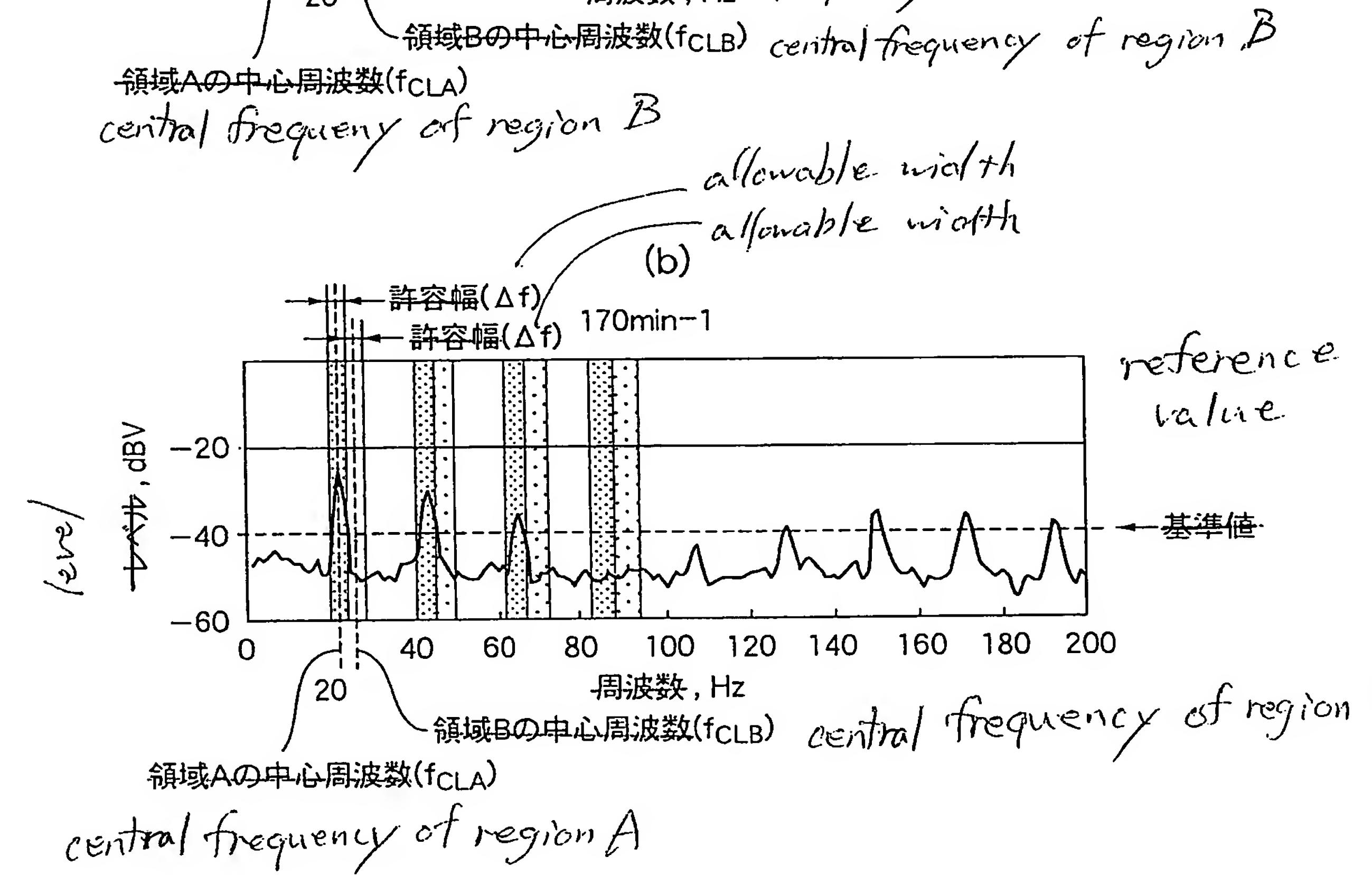
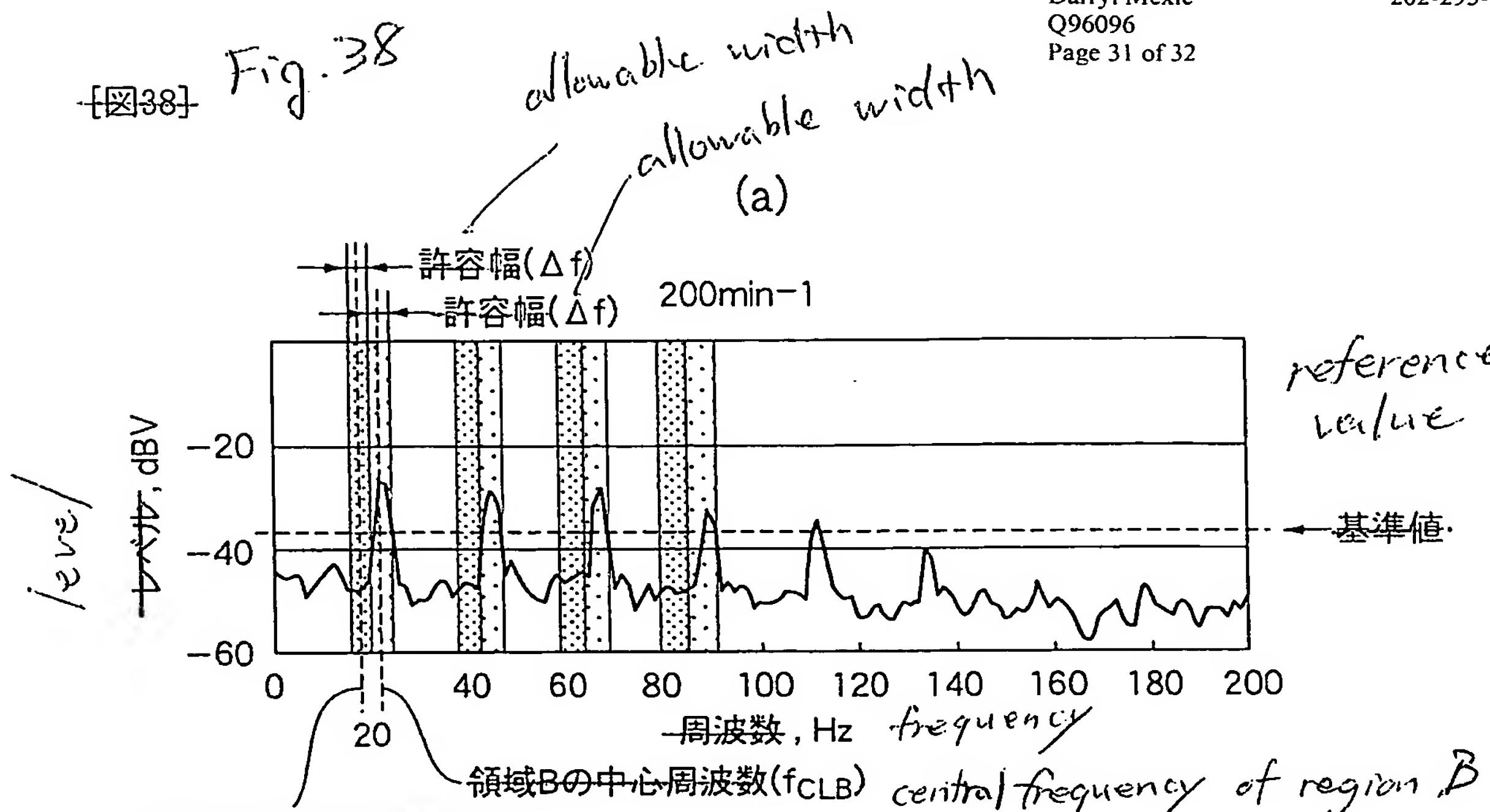


Fig. 39  
 [図39]

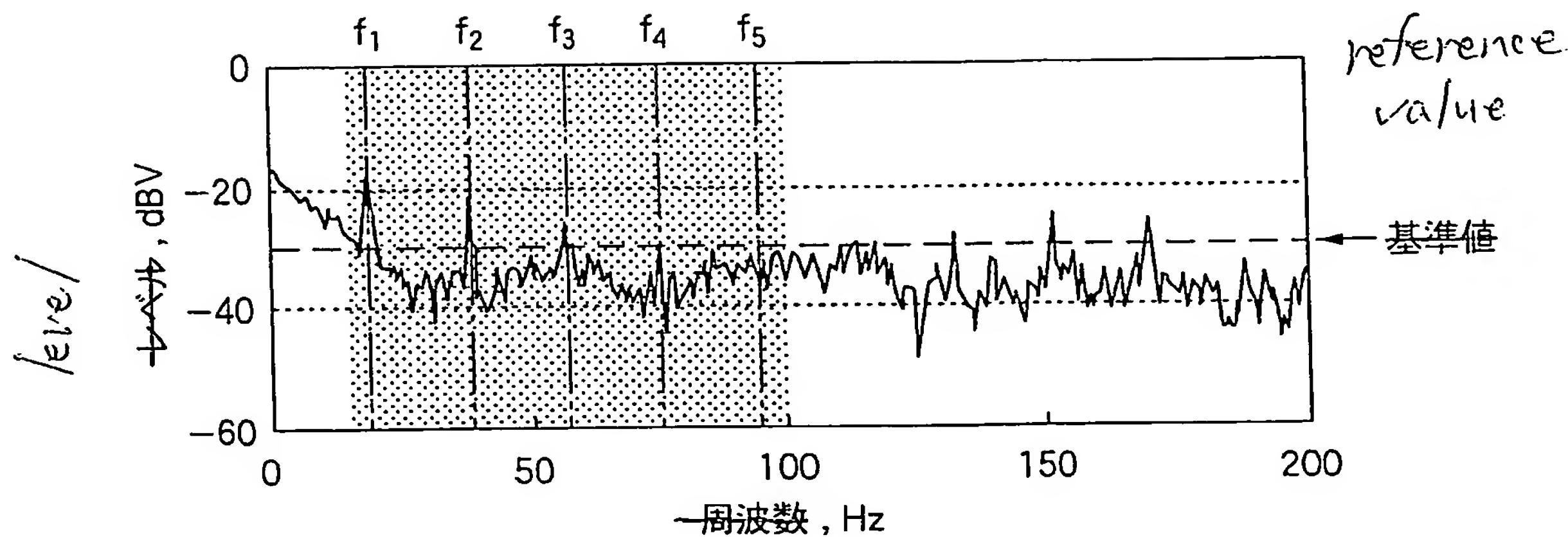
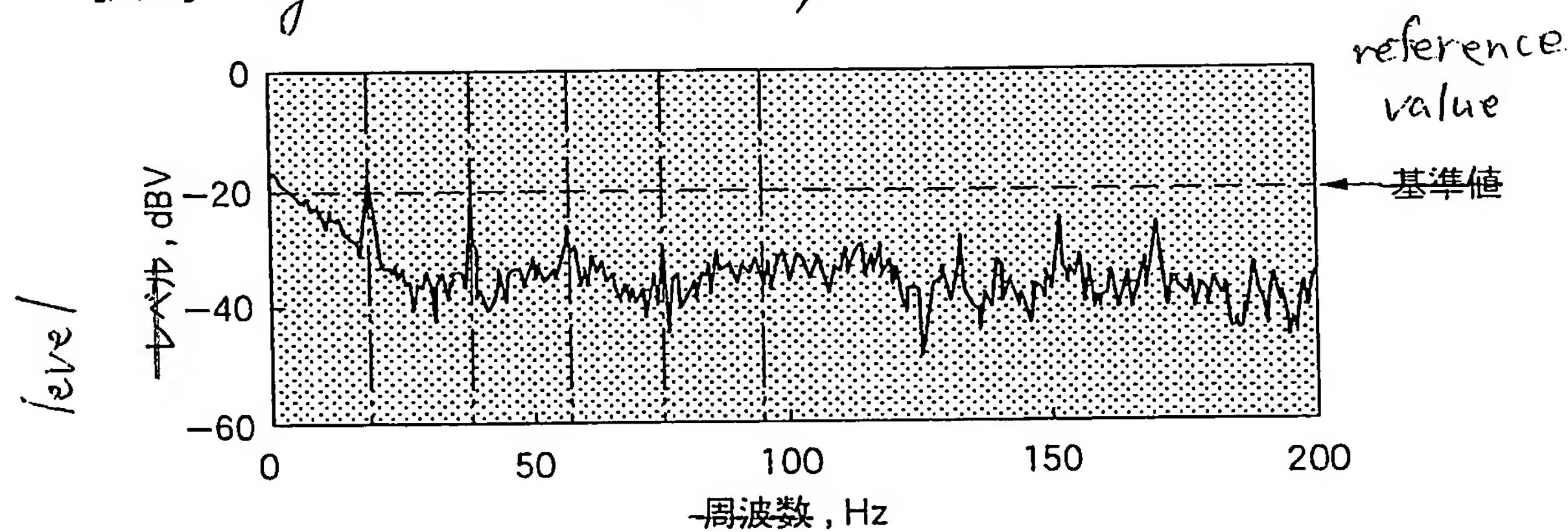


Fig. 40  
 [図40]



frequency